Key Challenges in Geography
EUROGEO Book Series

María Luisa De Lázaro Torres
Rafael De Miguel González *Editors*

Sustainable Development Goals in Europe

A Geographical Approach

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Key Challenges in Geography

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- provide a forum for geographers worldwide to communicate on all aspects of research and applications of geography, with a European dimension, but not exclusive.

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ISSN 2522-8420 ISSN 2522-8439 (electronic)
Key Challenges in Geography
ISBN 978-3-031-21613-8 ISBN 978-3-031-21614-5 (eBook)
https://doi.org/10.1007/978-3-031-21614-5

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Acknowledgements

In 2015, the United Nations approved the 17 Sustainable Development Goals (SDGs), which brought continuity and concern to the process initiated at the Rio Summit (1992) and the Millennium Development Goals (MDGs) agreed in 2000. Sustainable Development Goals are global goals, established for a period of 15 years (2015–2030). The goals are also known as the 2030 Agenda for sustainable development. The SDGs cover all possible social, economic, and natural aspects, both in a global and local space, that is, SDGs have an indisputable spatial and geographical approach. This EUROGEO book series collects some geographical evidences proving the scientific analysis of the complex process of sustainability from political, economic, and environmental challenges, which must be addressed from all areas of society.

Since the UN defined the importance of achieving equity in the world and leaving no one behind by formulating the Sustainable Development Goals (SDG) in 2015, most of the governments, companies, civil society, individual people, NGOs, and stakeholders in the EU have aligned themselves with the goal's aims. SDGs undoubtedly strengthen civic and democratic life in Europe. Geography has the potential to respond to these issues. The study of place, space, and environmental processes can help us understand and solve the real-world sustainability challenges.

Thus, the Jean Monnet Grant approved by the European Commission to EUROGEO in the GeoDem project (geography, democracy, European citizenship, and the digital age) promotes all these values. This work is also one of the outcomes of this Jean Monnet action. Each chapter is focused on one of the 17 different SDGs from a geographical approach. A total of 36 authors have participated in the book, without whom this publication would not have been possible. Finally, we want to thank the EUROGEO Board for the implementation of the Jean Monnet Grant, and particularly to Karl Donert and Luc Zwartjes, and to the reviewers for their excellent work that has improved any of the chapters with a wider vision, of course, and also to the Springer team, Doris Bleier, Carmen Spelbos, Sanjiev Kumar Mathiyazhagan, and Madanagopal Deenadayalan, for their patience along the book production process.

The book has an external evaluation and peer review; we thank for this work to the reviewers.

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SDG 1. End Poverty in All Its Forms Everywhere

SDG1 in Europe: Micro-grants, Poverty, and the Big-Picture Future of Sustainable Development in a Post-pandemic World

Julia Bello-Bravo, María Ángeles Rodríguez-Domenech, and Barry R. Pittendrigh

Abstract Impacts from COVID-19 have shown that efforts to expand economic inclusion for refugees are more relevant than ever. While facilitating such economic inclusion enables refugees to enter the labor market and provide for their own socio-economic needs, the challenges raised by COVID-19 allow international donors to reconsider more sustainable, local, innovative, and creative ways to support this. This chapter examines the discourse of one of the most sustainable new techniques to emerge over the last two decades: microfinance. Addressing Sustainable Development Goal 1 (End Poverty) in EU28, especially for immigrants experiencing economic precarity, this paper reviews theoretical, conceptual, and empirical contributions on the phenomenon of poverty in Europe to propose *micro-grants* as a more sustainable approach for refugee integration and meeting SDG1 to achieve SDG1.

Keywords Sustainable development · Micro-grants · COVID-19 · Digital communication

Introduction

The COVID-19 pandemic has radically altered what geography and experiences of it can mean (Aalbers et al. 2020; Wolman 2020). While the spread of the Internet gradually involved a majority of people across the globe—regionally at different times from 2015 to 2017—accessing digital information primarily using mobile phones

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_1

(Bello-Bravo et al. 2021), COVID-19 has forced a much more pressing and immediate use of the Internet on virtually everyone. This situation has moved the notion of the “video conference call” from a relatively unfamiliar form of human interaction, limited more or less to boardrooms and specialists, to a virtually foundational experience under COVID-19. Zoom, WhatsApp, and other digital platforms have become household words. As Wolman (2020) noted, “The coronavirus crisis is forcing us to reconsider physical space and our place within it.” For this chapter and achieving SDG1, the capacities of digital means to link together otherwise disparate places open up new possibilities for action and new affective connections far away.

In particular, an author of this chapter experienced this directly through a chance connection (on a social media platform) with a member of an oppressed minority in a South Asian country (anonymized to protect her identity). As a marginalized community, her people were excluded from national-level efforts to mitigate COVID-19—specifically, anti-COVID-19 materials were not made (and were not going to be made) available in her mother tongue. Thanks to this chance encounter, it was possible to produce anti-COVID-19 video materials in the woman’s mother tongue, which she could then distribute among her people. Being able to accomplish this hinged not only on a readiness and capacity to help produce this material for her but also monies to pay the labor to produce it. Conservatively, it cost approximately USD$300 to do so. This process exemplifies what we mean by micro-granting in this chapter. As a matter of principle, and in view of the good that can be accomplished by providing marginalized people such life-saving information during a global pandemic, one might very well simply offer to pay out of pocket. However, neither is this reasonable to ask of everyone for all such cases, nor is it fair to ask those who did the labor to volunteer their labor. Given that donor organizations have tens of millions, if not billions, in funds, that this kind of good for a marginalized community during a global pandemic might go not done because bureaucratic or other processes preclude disbursing USD$300 becomes embarrassing. As proposed in this chapter, micro-grants describe one such potentially new formal-informal channel for ensuring that opportunities for such positive benefits and outcomes are not missed.

These opportunities are everywhere. While poverty in Europe is a hard-to-measure phenomenon (Vergnat and d’Ambrosio 2021), recognizable swaths of poverty, inequality, and social exclusion persist, even in the most well-developed countries. Many places had not recovered from the 2008 recession before the COVID-19 pandemic negatively increased poverty and inequality. By 2020, 96.5 million people in the EU (21.9%) were at risk of poverty or social exclusion. Among these were 428,945 new asylum seekers (first-time applicants) who applied for international protection; nearly one-third of applicants (134,800) were children, 13,550 unaccompanied (Aura et al. 2020) (Fig. 1).

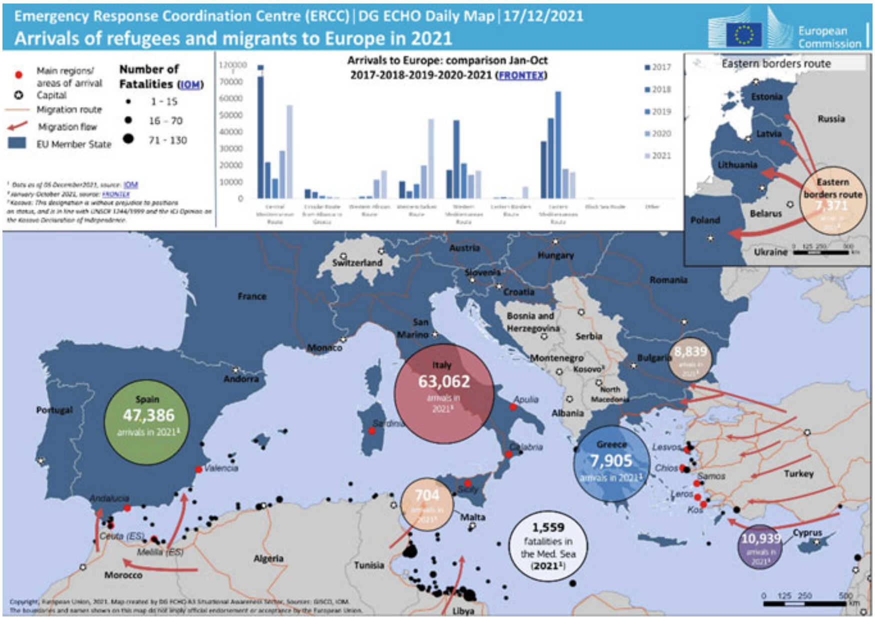

Fig. 1 Arrivals of refugees and migrants to Europe in 2021. *Source* ERCC (2021)

Performance of European Countries Against the SDGs 1: End of Poverty

According to Eurostat's definition, people living below 60% of their country's median disposable income rate are at risk for monetary poverty. Severe material deprivation means a person cannot meet four out of nine specific expenditures (e.g., having color television, heating, a washing machine). Finally, a household with very low labor intensity is one in which the working-age adults have worked less than 20% of the year. Over the whole of EU28, 3.2% of the population reflects at risk or severe material deprivation (see Fig. 2).

Both of these indicators are crucial for the assessment of poverty. Their differences reflect how some households may have saved or bought durable goods in the past, providing a decent material standard of living now despite low income. At the same time, other households may have an income above the poverty line without enabling them to meet all household needs. Both definitions give different pictures of poverty, so both are needed to adequately understand the extent of poverty in Europe. However, neither measure captures the intensity of poverty, i.e., how poor the poor are. Consequently, Eurostat also measures the relative-median-poverty-risk gap and the depth of material deprivation.

Risk of poverty or social exclusion affected 24% of the EU population in 2011, resulting from a combination of 17% of the population at risk, 9% facing severe

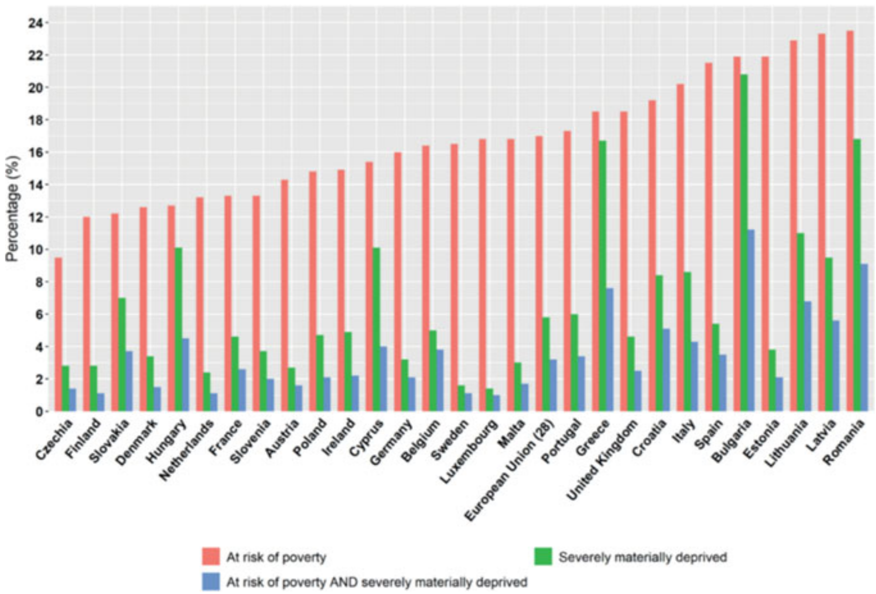

Fig. 2 At risk for poverty and severe material deprivation rates in Europe, 2018. *Source* IEB (2020, p 13)

material deprivation, and 10% living in low labor-intensity households. By 2018, the at-risk measure was unchanged (17%), with 5.9% facing material deprivation. Contrary to what is sometimes the conventional view, the rate of poverty and social exclusion in the EU remained essentially unchanged (stable) between 2007 and 2018.

This evolution masks markedly different trajectories by country (Fig. 3). While Europeans increasingly have access to goods and services for more adequate living conditions, the percentage of low-income individuals has tended also to increase (Vergnat and d'Ambrosio 2021, p. 12).

Because of its multidimensional nature, the measurement of poverty is complex and involves monetary and other aspects of living conditions; more precisely, its reliance on (usually materialist) measures as proxies for quality of life, social well-being (the second pillar of sustainability), and the like may not capture the actual qualities of life factors. That "man does not live by bread alone" (understanding "bread" also in its slang as "money") underscores how economic frameworks for assessing poverty risk both mismeasuring it and incorrectly understanding how to ameliorate the quality of life impacts (Hanlon et al. 2012). Therefore, it is often necessary to use not just different indicators but different indicator frameworks to comprehensively understand the phenomenon of poverty and give a better understanding of what is behind the word "poor."

Refugees living in low- and middle-income countries are especially vulnerable to the economic impacts of the COVID-19 pandemic. Based on data from eight hosting countries before COVID-19, we find that refugees are 60% more likely than host

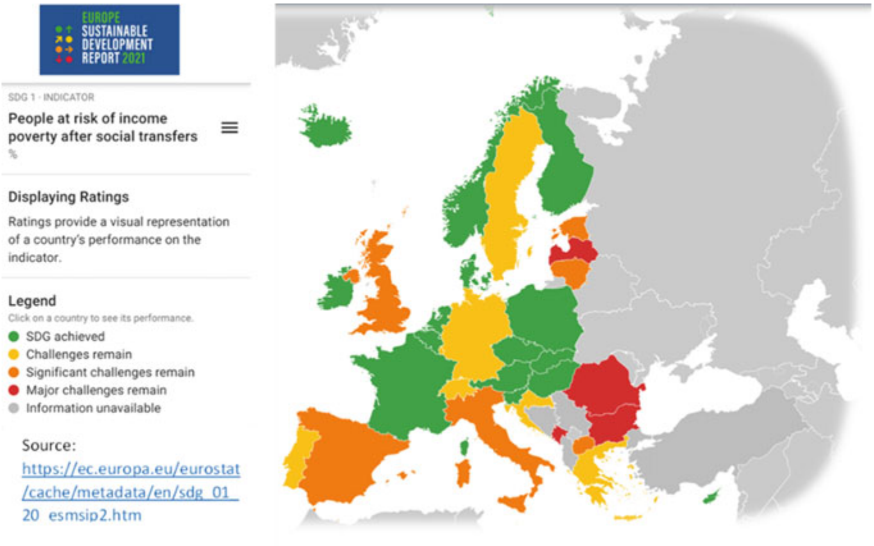

Fig. 3 Performance of European countries against the SDG1 ("End Poverty"). *Source* SDSN (2021)

populations to be working in highly impacted sectors, such as accommodation and food services, manufacturing, and retail. As a result, COVID-19 will likely lead to widespread loss of livelihoods and increased poverty among refugee populations (Siche 2020, p. 1).

In this context of addressing Sustainable Development Goal 1 (End Poverty), one of the most sustainable new techniques to emerge over the last two decades has been microfinance, understood as the provision of financial services (loans, savings, insurance, or transfer services) to low-income households (Parker 2001). This chapter proposes *micro-grants* as a novel form of sustainable international development able to help achieve SDG1 in EU28, especially for immigrants experiencing economic precarity. COVID-19 has shown that efforts to expand economic inclusion for refugees are more relevant than ever. Facilitating greater economic inclusion will enable refugees to enter the labor market and provide for their own socio-economic needs (Siche 2020).

Micro-grants: Sustainable Approaches Through Local Innovation and Creativity

In general, grant processes involve vetting applicants for the bona fides to produce some new knowledge that otherwise would not have occurred without the grant (Taylor et al. 2017); this also includes affirming their capacity to service the grant and produce the grant's deliverables. Usually, these processes occur on a fixed cycle. Accordingly, we motivate micro-grants below by "informalizing" these typical granting elements to become more sustainably accessible, especially at scales faced by small groups of people or individual persons.

Vetting Grant Applicants

A commonplace in grant funding involves ensuring that would-be projects align with the donor's goals and objectives and that the applicant has the bona fides for successfully managing and completing the grant (Reif-Lehrer and Adler 1995). Rational as this might seem, considerable research documents inequalities in these processes, e.g., unequal assessments of bona fides in qualified female grant applicants (Bornmann et al. 2007; Jerrim and Vries 2020; Steinþórsdóttir et al. 2020). Further, Sanya (2017) demonstrates how situations involving discretionary judgment subject a petitioner's application to an assessment of its alignment not only with *administratively* expected but also *culturally* expected norms, with those petitions exhibiting fewer markers of the culturally expected norms less often having their petition administratively validated and accepted.

This can, and frequently has, served racial and gendered inequality agendas on large and small scales across numerous discretionary contexts (Keiser et al. 2004; Nanda 2011; Yang 2015). However, it also operates in the absence of such agendas because the administrative expectations themselves are already culturally marked (Sanya 2017). Accordingly, grant petitioners must navigate a donor bureaucracy's culture to secure a grant (Reif-Lehrer and Adler 1995). The sheer volume of "how-to" studies and books for writing grants specific to various sub-specialties testifies to the uniqueness of the cultures and the requirements in various sub-fields (Chung and Shauver 2008; Gholipour et al. 2014).

Plainly enough, to expect organizations to accommodate everyone's needs is untenable (Reif-Lehrer and Adler 1995). However, we should count it a seriously lost opportunity when a locally great idea or potentially game-changing endeavor languishes for want of adequate support. All the more so if that support gets withheld because a local effort missed an international grant deadline, filled out the forms incompletely or incorrectly (or incoherently, given little facility with the grant funder's language), or in some other way failed to match the bona fides expected by the funder.

Intermediaries for Linking Providers and Recipients

A mechanism or pathway is needed to bring locally worthy causes to the attention of global funders. Often, an experienced grant writer is one such pathway (Wedding 1997). However, while such grant-writing intermediaries can afford meeting and linking both the administrative and cultural expectations of a funder, cost and availability will often be prohibitive for poorer people. Additional varieties of intermediary are needed.

Micro-grants envision a formally designated pool of resources that vetted grantees access informally. This resonates with one of the earliest articulations of micro-grants by Pfaff (1973), who proposed them explicitly through a critique of conventional large-scale granting processes. While this mandates proposals for templates or protocols for implementing such informal vetting processes for formally earmarked resources in a way that is efficient, fair, and not subject to dominant forms of abuse (Mom and Sandström 2018), administrative and cultural variance in each organization also necessarily requires developing these in culturally competent ways, i.e., as organization-specific, -relevant, and -feasible practices.

Advocacy for cultural competence typically argues that more empowered stakeholders in some distribution network of goods (whether resources, education, or capacity building) should take more account of recipient stakeholder values when deciding on, developing, and distributing those goods (Abrams and Moio 2009; Johnson et al. 2006; Purnell 2002). However, while research can over-position cultural competence as something that global Northerners ought to acquire vis-à-vis the rest of the world (Abrams and Moio 2009), it can be equally seen that intra-organizational cultural competence must consist of and reflect practices that are institutionally legible, especially when proposing changes.

This emphasis is intra-organizational only and speaks specifically to the necessity for each institution to develop its own culturally legible and competent processes for micro-granting and institutional changes to implement it (Argote and Ophir 2017; Karim and Kaul 2015; Ngwenyama and Nørbjerg 2010). Whatever the ultimate form of this micro-granting process it must be workable for all stakeholders involved, petitioners and petition-granters alike, just as sustainable development's calls for participatory designs must fairly negotiate the needs of all involved stakeholders (Læssøe 2010). For some micro-granting institutions, there may already be discretionary, operating, or "slush" funds for enabling non- or informal projects that could then be tapped for micro-granting. Other institutions may require more formal resources allocations to supply funding, but their distribution to petitioners will still need to occur in an expeditious, simple, and non-bureaucratic way. Whether as individuals or as processes for informal grant funding, these intermediaries serve to connect micro-grant donors and recipients.

Timeliness

In part, the informality of these processes reflects a necessity to respond quickly to developing situations, especially in times of emergency. Too often, a need to get *some* message out quickly may overrun formal procedures to ensure the accuracy or relevance of the information. As such, because bureaucracies can be "cumbersome, rigid and inefficient; that they enshrine procedures at the expense of substance; that greater specialization, if uncoordinated, does not improve the quality of services rendered to individual clients or to the community as a whole" (Spangler 1986, p. 459), any culturally competent procedure for micro-granting must also be flexible, resilient, and adaptable enough to respond in emergency time (Gunderson 1999). The practical upshot of this is that no grant cycle governs the timing of micro-grants.

Supporting the Social Pillar of Sustainability

To repeat, we frame any provision of micro-grant resources (monetary or otherwise) specifically as a *grant*—not a micro-loan for entrepreneurship (Garg and Kaur 2018), that kind of conditional cash transfer (CCT) first popularized in Mexico that then spread more widely around the world (Garcia and Saavedra 2017), or the evidence-backed proposal from Hanlon et al. (2012) simply to give money to the poor. Instead, we echo Taylor et al. (2017), who insist that the "various agencies that provide grants do so *to make possible a research project that might otherwise not occur*" (p. 460, emphasis added). While this experimental or research motivation for granting can be bound up (sometimes inextricably) with institutional or personal prestige, securing returns on investment, or affording or creating (political) alliances around the globe (Desai 2017; Engerman 2010; Madela 2020), this stated aim to contribute to knowledge that would otherwise have not existed (and so would never have been available for distribution to others who might most benefit from it) remains arguably the most authentic and humane aspect of grant-supported sustainable development.

Given the extensive literature on the effects of competitiveness and the shaping of research agendas by externalities like citation networks, fundability, and nepotism around grant awards (García and Sanz-Menéndez 2005; Parent et al. 2018; Sandström and Hällsten 2008; Shore 2005), there is a risk of idealization here in highlighting the specifically social contribution that grants make possible for knowledge. However, applying a financial, political, or self-interested hermeneutics of suspicion (Akrivoulis 2017) to every activity of sustainable development risks oversimplification just as much as idealization. While the relation of micro-grants to the overly dominating values of the *economic* pillar of sustainable development cannot be completely brushed aside, they nevertheless include an equally non-negligible emphasis on sustainable development's social (if not also the environmental) pillar as well.

Grant Management and Oversight

A central part of establishing bona fides in potential grant recipients involves the attempt to ensure that the resources provisioned go to the cause identified and are not squandered somehow. Here, the problem of cultural competence—whether intra-organizationally, as grantors develop administratively legible means for connecting resources and grant applicants, or cross-culturally, when grantors recognize the legitimacy of applicants, even when they do not strictly conform to expectations—is compounded with the question of management and oversight of the grant. Specifically, because any such management or oversight must involve an expenditure of time and labor, it is reasonable that whoever performs those functions would be compensated.

The specifics of any potential grant situation may rule out the question of providing institutionalized compensation. Nevertheless, the question "What about management and oversight" must still be answered (and not by insisting on volunteer labor, since far too much labor around the world is already tacitly and unjustly not paid for). Rather, one can point to the threshold where the needed funds for management and oversight are small enough. Institutionally, this threshold rationally occurs where the costs of management and oversight for tracking the grant administratively are higher than the grant amount itself. Further pursuing this insight, if the grant amount falls below the threshold of funds that can be cost-effectively tracked, then the intention behind vetting grantees to ensure that they use provided resources for the purposes intended becomes unnecessary. More generally, these issues around micro-grant management and oversight raise questions about any contractually agreed-upon responsibilities by the parties overall (who does what, where, and when) (discussed further below).

For micro-grants, this situation requires "re-thinking" grant contracts in more informal terms (see "Trust and Grant Formalization" below), if not abandoning them in general. For management and oversight, that intermediaries recommend projects for micro-gra will likely occur because already-underway projects have some effective (internal) oversight and management. In other words, the "effectiveness" and "grant-worthiness" of the project is implicit in the judgment of the intermediary.

In general, grant management and oversight have the dual purpose of coordinating an often large and disparate number of entities toward a common goal and ensuring that those elements do what needs doing for the sake of that coordination (Munyao 2017; Powner 2008). Studying formal granting processes for self-help groups in Kenya, Munyao (2017) advocates hiring additional oversight officers despite already-existing funding shortfalls limiting what the self-help groups can accomplish. While it may seem difficult to understand how adding overhead to already resources-straitened (self-help) groups could achieve the goal it aims for, this recommendation is also the only kind of suggestion that formalized grant processes understand or acknowledge. This situation then, in turn, demonstrates the limited applicability of formal grant processes in such contexts. In contrast, for micro-grants, no large-scale coordination comes into play in the first place, and the oversight-desire to ensure that the grant is fulfilled—ignoring the fact that it would cost more to administer and manage the grant than the micro-grant itself—can be met simply by the deliverables of the micro-grant (described below).

Grant Deliverables

As grants afford knowledge production that would not have otherwise occurred (Taylor et al. 2017), so must micro-grants similarly accomplish this goal. For formal grants, this often involves at least a final report as a return on the project (if not also midway or milestone reports). However, the non-formal aspects of micro-grants require equally non-formal reporting strategies—in part to keep at a minimum any overhead for management and oversight but also because expecting local projects to know, follow, or even have the means to generate (in an alien dialect) a formal report is untenable (even were it possible to pay a third party or intermediary to prepare such a report).

Instead, it can simply suffice that the micro-grant recipient documents their work or project product in whatever form is most convenient and cost-effective. This serves a second function as well, in that it orients micro-grants specifically toward activities that have a public dissemination aspect in the first place. Very often, in grant contexts (where knowledge that indeed would not have otherwise occurred is generated), that new knowledge never gets more widely distributed than to the recipients of the final report. There is indeed a severe gap between research and getting the findings of that research to members of the public who could directly benefit from it (Bello-Bravo 2020a, b).

Here again, intermediaries are critical. As people in the sustainable development community travel and communicate, they encounter not only already-existing implementations of ideas (as projects and practices) responding to local manifestations of problems but also excellent and novel approaches languishing for want of resources. Intermediaries can also receive recordings or documentation of grant activities in emails or other media for delivery to designated grantors as evidence of the micro-grant's completion. This mirrors formal granting processes, where such reporting can serve as the basis for awarding similar future grants.

Trust and Grant Formalization

As for contracts generally, a rationale for documenting grant responsibilities, deliverables, timetables, benchmarks, and reporting requirements involves both clarifying and memorializing any established agreements between parties wihle also providing evidence in any legal action that a breach of those established agreements has occurred (Miller and Jentz 2006). However, contracts do not enforce compliance but instead establish the threat of seeking relief through legal channels (if a party can afford it); hence, "Individuals agree to perform certain tasks and, with the execution of a contract, that private agreement is given the force of law" (Goldblatt 2008, p. 15). As such, while contracts provide a mechanism for risk mitigation, their underlying premise remains rooted in some measure of trust that all parties will behave according to the terms of the agreement. Goldblatt (2008) usefully underscores this distinction in the movement from contract to social contract, i.e., through the interdependence of formal and informal arrangements between people, given that "a contract is only valid and enforceable because the individuals involved in the contract chose to be bound by its terms before it became enforceable" (Goldblatt 2008, p. 15). As such, a contract's formal mechanism for risk mitigation mirrors trust as the risk-mitigation mechanism in informal (non-contractual) agreements.

Given the (literally) unmanageable character of formal grant contracting (for both potential micro-grant applicants and grant funders), micro-grant agreements must rest (as all contracts do) on that basic foundation of trust. Establishing such trust, then, becomes the primary aim of any micro-grant negotiation or provision. Vouchsafing by intermediaries is one of the main channels for establishing this trust. However, the further implication is that if the grant amount is too small for the institution to "care" about, why would it not remain equally indifferent to how the funds are spent, whether the grant recipient delivered deliverables and the like? (These questions bracket out the fact that the costs for a granter being non-indifferent to these issues will undoubtedly outweigh the amount of the grant itself).

Micro-grants need not (and would not) preclude due diligence and compliance, but we must emphasize again that this proposal does not involve simply giving out money (Hanlon et al. 2012). Rather, micro-grants grandfather in and integrate the main gestures and goals of formal grant provisioning—above all, the generation of knowledge and its concomitant social benefits that would not have happened otherwise (Taylor et al. 2017)—but render this integration in culturally competent ways on a small enough scale for informal grant applicants.

Under such informal constraints, trust already suffices where formal contracts are unavailable or impossible (Gambetta 1988; Rosanas and Velilla 2003) as an essential and vital part of everyday interactions under formal/contractual settings (Lutomia 2019). To put this in a slogan: one might do without contracts but not without trust. In this sense, trust simply represents "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer et al. 1995, p. 709). That an intermediary can vouch for a local (grant-worthy) project in need of (emergency) support during a community disruption signals such informal trust to the granting institution. Moreover, such trust is further enhanced when "institutions and procedures generate an impeccable record in terms of truth-telling, promise-keeping, fairness and solidarity" (Offe 1999, p. 85).

While such trust involves risk, this also highlights a need for adequately flexible decision-making around selecting the most appropriate risk management strategy (i.e., mitigation, avoidance, or acceptance, rather than some blanket policy-refusal to engage risk at all. (Such blanket risk aversion can be extremely risky in a context like COVID-19, where fast-changing circumstances not only make risks difficult to weight in the first place but also threaten high-stakes consequences from inaction.) For example, Hajmohammad and Vachon (2016) outline parameters for such flexible decision-making around risk management strategies. Specifically, they note that *a party's social or environmental misbehavior* (Hajmohammad and Vachon 2016) will often mandate risk avoidance (if not actual termination of association with the offending entity) as the appropriate strategy. This recommendation echoes the observation by Gill (2012) that unethical behavior in an associate deeply undermines trust and can place the association in jeopardy. Lutomia (2019) similarly documented that unethical conduct by collaborators could not only lead to a termination of association as soon as possible (and no interest in the future collaboration) but also a sour taste for collaboration left in their mouths in general. More generally, one may say that a violation of trust justifies risk avoidance (in contrast to risk mitigation or risk acceptance).

For micro-granting, taking into account the three factors of (1) the small sums involved, (2) the record of recommendations by any intermediaries for various micro-grant recipients, and (3) the non-interdependence of the granting institution on the grant recipient as factors in risk management decision-making in general, this motivates risk *acceptance* as a rational organizational choice under micro-granting, especially in fast-moving emergencies where more timely responses have more significant effects.

The Threat of Success

Farson and Keyes (2003) discuss the risks of failure that success can bring, particularly when an upsurge of organization visibility or popularity overwhelms its existing capacities. Admittedly, while outlays for any given individual micro-grant are, by design, relatively minimal, a potential hundred if not thousands of such grants occurring at once instantly multiplies those negligible costs to potentially onerous levels.

This re-emphasizes that the *social* pillar of sustainable development could bear this problem (Afful et al. 2019). That is, it would be unfair (if not also infeasible) to ask granting institutions to shoulder the burden of potentially hundreds or thousands of micro-grants. Equally, "outsourcing" that task to a third party would justly require compensation for such services and thus incur costs that need covering. While this situation might prompt imagining the founding of an organization specifically to provide funding (or to channel funding), support, and management/oversight for any such volume of micro-grant servicing, this merely reproduces the existing problems of (formal) granting or shifts them to some, as yet not imagined, different organizational location. Again, bringing the social pillar of sustainability into the picture helps negotiate these issues.

Re-"Viewing" Sustainable Development

An implicit assumption in the preceding is the notion of organizations as individuals (resembling the individual "hero's" template as an actor during an emergency). As such, instead of lone organizations addressing micro-grant applications autonomously, a structure of distributed (shared) responsibility would more fairly, and thus more feasibly, support even high-volume micro-grant servicing. Such collective effort and solidarity evoke the social pillar of sustainability (Afful et al. 2019) explicitly. Traditions of modernist individualism (and their formalities in contracts) contrast the individual with the collective (and its informalities of trust) in polemic and typically mutually exclusive ways. Thus, Goldblatt (2008) can note, "For modern scholars, contractualism implies individualism and vice versa" (p. 16). Whatever the merits and advantages of this identification, it similarly tends to position institutions as more favorably and strategically better off when individually isolated from others compared to operating as a collective in some sense. For this reason, despite the numerous forms of legal and extra-legal inter-organizational structures that have evolved to bridge from individual organization to individual organization, critiques of such bridging persist (c.f., Longoria 2005; Sydow et al. 2016 for a broad discussion of these critiques).

In contrast to this specifically modernist notion of individualism—founded on a "basic (nominalist) assumption that only individuals (entities with aims) exist, not social wholes (societies and social institutions) … All versions of individualism share the denial that societies have aims or destinies" (Agassi 2017, p. 1)— indigenous and African notions like "it takes a village" reflect a threefold image of (1) social sustainability through solidarity, (2) distributed responsibility for the wellbeing of the community as a whole, and (3) a sense of personhood (not individuality) embedded within that social matrix of solidarity and community.

If this seems too abstract or inapplicable to micro-grants, it links the "goodwill" of micro-granting to long-standing, historically tenable models that persist as alternatives to a form of modernist individualism that denies the reality of social wholes, communities, collectives, collectivities, or simply groups and thus any sense of non-selfish, collective responsibility. As such, it echoes or runs parallel to tropes within "western" discourse concerning notions of distributed responsibility as well (Floridi 2016).

Moreover, although the fundamentally autonomous framing and legal structuring of large-scale granting organizations make efforts to establish systems of distributed responsibility across collaborative, corporate, and meta-informational contexts challenging (Afsarmanesh et al. 2004; Power 2019; Saran et al. 2008), these very successes demonstrate not only the possibility of doing so but also how a culturally competent approach to these challenges can span multiple organizations—in the same way that the collective culture of a village reflects the individual (and unique) personhood of each of its inhabitants.

That such a structure of distributed responsibility could support any volume of micro-grant petitions may more involve a change of mission or attitude than the kind of "major system overhauls" envisioned by Ioannidis (2011, p. 529). At a minimum, distributed responsibility manifests in the difference between "we don't do that" ("I can't help you") versus "I can't do that right now (or don't know how to), but I'll connect you with someone who does." While "villages" typically have hundreds, if not thousands, of years of intra-organizational networking traditions to build on, for sustainable development as a whole, (re)making, rediscovering, and (re)connecting those linkages as traditions will require time but can accelerate the process by learning from others' efforts. Here again, intermediaries become essential for witnessing and then sharing those traditions to large-scale granting organizations.

Conclusion

This chapter outlined (1) the increasingly urgent necessity for sustainable development channels that respond quickly to emergent issues, whether emergencies or not, and (2) some of the main characteristics of micro-grants that afford sustainable development efforts the capacities needed to achieve SDG1.

This requires recognizing and taking seriously the role of sustainable developmentalists for poverty elimination in EU28 and beyond. This can be neither monodirectionally "giving" solutions to local people (including refugees) nor "giving" such people their "freedom" to work out their solutions without our help; the former is unworkably condescending, while the latter condescendingly reneges on our collective responsibilities. While empowering people means enabling access to a world of game-changing solutions, whatever further global strategies emerge from the currently shifting geography of the world and the downstream effects of COVID-19 for refugees, we can also listen and learn from our global/local friends and elaborate a developmental sustainability that supports existing (or imagined) local projects toward reaching SDG1.

As proposed in this chapter, micro-grants describe one such potentially new formal-informal channel for ensuring that opportunities for such goods are not missed. Currently, established university programs like Scientific Animations Without Borders (SAWBO) can work with NGOs to afford informal service providers with educational approaches that enable micro-grants among diverse groups. For instance, during the COVID-19 pandemic, SAWBO-RAPID funding by USAID to minimize the secondary effects of COVID-19 recruited local individuals for translating animated anti-COVID-19 videos into local languages through micro-grants. In principle, however, every institution can provide a pathway for micro-grants. The main barrier to doing so (absent some ideological stance that people do not "deserve" help or "free" money) involves setting aside any existing bureaucracies for disbursing money that generate front-end or administrative overheads in excess of the micro-grant amounts. It will definitely be possible for any well-funded domestic or multinational institution to find its own (unique) way to do this. In this sense, implementing micro-granting becomes a question of leadership and will, not money or risk assessment.

The ongoing reconfiguration of geography under COVID-19 makes this leadership and will more urgent and more visible. COVID-19 drove people together virtually, while worsening refugee situations have brought together people physically, face-to-face. These situations personalize our encounters with others on the sidewalks of the world community, such that activity (like helping a woman to obtain anti-COVID-19 information for her community in her mother tongue) becomes possible.

The pace of this information age also affords enormous strategic possibilities, so long as sustainable development can react adaptively, resiliently, and flexibly to the new technological opportunities. Turning the slogan "think globally, act locally" into a sustainable, developmental mode of action over new geographies is (already) possible. By turning the slow-turning aircraft carrier of development into a lithe, flexible, quick-moving skiff, institutions (each and severally) can articulate culturally intelligible micro-grants as a means for reaching SDG1. Such efforts afford small scale (even tiny-scale) but enormously beneficial support for environmental, social, and economic projects that cannot otherwise occur.

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SDG 2. End Hunger, Achieve Food Security and Improved Nutrition, and Promote Sustainable Agriculture

Geography: Origin of the Complexity of the Food System

Yvonne Colomer Xena

All Human Rights are inherent and indivisible. But one of them, the right to life, is the supreme right because it determines the exercise of all the others. For this reason, the right to food is fundamental and we must all contribute, in our daily behaviour, to make sure that nobody is excluded from this essential facet of human dignity.
Federico Mayor Zaragoza
Honorary President of Triptolemos Foundation
Former General Manager of UNESCO (1987–1999)

Abstract Geography imposes barriers. These barriers hinder and limit the movement of people and create environments with defined characteristics. Globalization and the added effects of climate change have increased migration. New cultural food systems have proliferated in large cities, seeking a balance between purchasing power and satisfaction, which will coexist in certain cases with genuine aspects of traditional food identity. The important interrelation due to globalization of the cross effects between cause and effect in the food sector (e.g. climate change-food-migration-hunger or obesity-education-economics) is highlighted as indicated by the United Nations in the 2030 Agenda and its Sustainable Development Goals. The right to food is fundamental, and we must all contribute, in our daily behaviour, to make sure that nobody is excluded from this essential facet of human dignity. It is no coincidence that this is Goal 2, Zero Hunger. The Triptolemos Foundation considers that only from the approach of a sustainable global food system, which includes the availability of food, the economy, policies and culture, all of them interrelated and in balance, with the support of science, technology and responsible business activity, can we face the food challenges of the XXI century with a minimum guarantee, included Zero Hunger, and aligned with the 17 Sustainable Development Goals (SDG).

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_2

Keywords Food and Geography · Food sustainability · Global food system · Availability and accessibility · Economy · Policies · Culture · Education · Triptolemos · ITRIn index · Climate change · Water · Zero hunger

Zero hunger. Goal 2 aims to end hunger and all forms of malnutrition by 2030. Triptolemos Foundation©

Climate change, conflicts in various areas of the planet and for various reasons, uneven and unstable economic growth and an increase in inequalities are all factors that contribute directly to an increase in poverty and hunger in the world. FAO's projections for 2030 are not promising; an increase in the number of people suffering from food insecurity is expected from the current 811–900 million. We are moving away from achieving Sustainable Development Goal 2, Zero hunger.

The Triptolemos Foundation for the development of the food system was created in 2002 with a universal projection under the Presidency of Mr. Federico Mayor Zaragoza, Former General Manager of UNESCO (1987–1999). The Foundation contributes to optimize the food system with its activities and thus achieve adequate food for the entire population, the confidence of the consumer and the dignity of the sector. The motor of the system is responsible business activity. Its vision and activities are supported by validated and updated scientific knowledge. Today, it includes 26 universities, the CSIC (*Spanish National Research Council),* companies,

UNESCO
United Nations Educational, Scientific and Cultural Organization

uniTwin

UNED

UNESCO Chair on Science and Innovation for Sustainable Development: Global Food Production and Safety
Triptolemos Foundation for agrifood development

Fig. 1 UNESCO chair "Science and innovation for sustainable development: global food production and safety" logo (*Source* Triptolemos Foundation)

Fig. 2 UNESCO publication "Humanistic futures of learning" cover (*Source* UNESCO)

consumer associations and various representative institutions among its members. With a projection both nationally and internationally, it is open to any new additions which share its goals.

Triptolemos's approach and actions have led to recognition by **UNESCO** with the creation of the Chair "***Science and Innovation for Sustainable Development: Global Food Production and Safety***" (Fig. 1) with the UNED (National Distance Education University), from which the Foundation develops part of its activities (Martin et al. 2020). The Foundation is also a member of the Global Soil Alliance and the Global Food Safety and Nutrition both FAO working groups, among others.

Food systems constitute the largest economic system in the world in terms of employment, livelihoods and planetary impact; 4 billion people work directly or indirectly in food systems. However, hunger and poverty persist in endemic form in all the world.

By describing in general terms how the Triptolemos Foundation (Fig. 2) interprets the global food system (UNESCO, 2020), it will be possible to have a better understanding not only all the importance of the SDG 2, **zero hunger** objective but also the relationship of food with the rest of the **SDGs and geography**, all of them are interrelated.

Geography Imposes Its Barriers

If we refer to the planet, approximately **75% is water and 25% is land**, with 3 large continental masses: Eurasia, America and Africa. Of this 25%, 9% is dedicated to non-primary uses (cities, roads …), 8% mountains and forests, 7% permanent pastures and only 3% of the total surface of the planet is used for permanent crops. That is, **barely 10% of the total surface of the planet is related to food uses** (agriculture, pastures, forests …). These percentages have marked the development of the food systems.

These barriers have hindered and limited the movement of people. They limit it in an environment with defined availability and characteristics. In this environment, man must subsist by creating his own food system. Transportation techniques have been advancing slowly and have facilitated exchanges between populations. Some of these exchanges have been fundamental in the alimentary aspects. Globalization and the added effects of climate change have **promoted migrations**. New cultural food systems have been promoted in large cities, seeking a balance between purchasing power and satisfaction, which in certain cases coexist with genuine aspects of traditional food identity.

Development of the Food System in Three Major Stages

In this environment, humanity has developed the evolution of its several food systems (UN Food Systems Summit 2021), with tendency to a one global food system in 3 major stages (Fig. 3). This approach will help to better understand spatial problems through the concepts of the Sustainable Development Goals (SDG's):

The **first stage** originates from the first population movements from the Neolithic Era until the discovery of America (fifteenth century). This stage is characterized by restricted mobility due to little technological advance, which resulted in a stage that we can call closed systems, some exceptionally so. Some examples could be the culture of the Inuit, Polynesia, the African jungles or the cultures in the great valleys of Europe or America. Geography and climate determine agriculture, livestock and cuisines. At this stage, there were some larger nuclei, such as the countries around the Mediterranean Sea or the China Sea, which constituted somewhat more open food systems thanks to the sea and with incipient trade.

At this stage, we can refer to Marco Polo's travels, the spice route, among others. But the journeys were by land with what little could be transported. This first stage is also characterized by the sacralization of the food system. Regulations were introduced into the food system through religion. We find examples of this in Christianity, Judaism, Mohammedanism …

In the first stage, the development of the food system was done mostly carried out by land. Stable products with high added value in the cuisine, such as spices, were

Fig. 3 International trade is crucial in the exchange of food. Salón Alimentaria. Triptolemos Foundation©

traded overland, with some exceptions such as maritime trade in wine, oil, cereals, beers in the Mediterranean or salted foods in the area of the North and Baltic Seas.

The **second stage** begins with the discovery of America, and it lasts until the end of the Second World War. The discovery of America and crossing the Atlantic are important events in the development of the food system. Let us bear in mind that with the belief that the earth was flat, Gibraltar meant the end of the world as it was believed that great precipices existed, and this greatly conditioned exchanges. In this second stage, it is verified that the earth is round and there is great concern to explore the planet. Technological advances and the strengthening of maritime travel facilitate product and seed exchange. At this stage, the world population was around 450 million people.

The integration of the world economy after the Age of Discovery allowed an exchange of crops on a planetary level: products from the Old World, both from temperate zones such as wheat and grapevines, as well as from warm zones such as sugar cane, cotton and coffee, were successfully introduced in America, while New World products such as corn, potatoes, tomatoes, peppers and tobacco diversified European agriculture and the rest of the continents.

In this second stage, the globalization of the food system slowly begins with the exchange of products. However, we still cannot refer to the globalization of the cuisine; that is, we still cannot speak of the globalization of culture. There was an exchange of food cultures, but in a very restricted way, not at a popular and massive level as we understand it today.

Humanity has advanced extraordinarily throughout history, accepting and adopting the innovations that have been produced in all disciplines. Thanks to the development of knowledge and innovation, increases in productivity and quality of agricultural products and, to summarize, the profitability of agricultural exploitation has been achieved. Humanity has been particularly bold in its diet, for example by incorporating exotic plants from different continents. The acceptance in Europe of species such as potatoes or tomatoes of American origin in the sixteenth century could not have been easy (Beltrán et al. 2020).

In this second stage, it was Europe which directed the great voyages. The European coasts were schools for sailors; we refer to the vikingos or the Spanish-Portuguese culture with Magellan and Vasco de Gama and the English with the voyage of Captain Cook or the Dutch, Jan van Riebeeck, the scientific expeditions of Darwin among others. China was isolated at this stage. The second stage is an important technological advance. The development of the food system is made by sea, and it is reinforced mainly by the exchange of products. Technology propelled the initial shift from local food systems to global ones.

It should be noted in this second stage that the FAO was created on October 16, 1945. FAO is the **Food and Agriculture Organization of the United Nations**, in which more than 194 countries are represented and their mission is to contribute to building a world where food security prevails for present and future generations. Its 75th anniversary was celebrated in 2020, and its General Director, Mr. QU Dongyu, referred to the fact that a comprehensive reorganization of the world's food systems is one of the most powerful tools we have to change course, move towards achieving the 17 Sustainable Development Goals (SDGs) and "building back better" after the COVID-19 pandemic.

The **third stage** goes from the Second World War (1939–1945) to our times. This stage is characterized by significant progress in two major areas: scientific/technological and cultural by the exchange of cuisines and cultures which occurs in a very important way.

In the scientific/technological area, the advances in plant genetics, among others, stand out. This generates initiatives such as the Green Revolution that began between 1945 and 1960, which led to a strong increase in production, and the development of varieties resistant to specific situations. The negative aspect is the scarcity of water and, in addition, part of the agricultural production is part of the strategy of the global energy economy and with this, food resources are used to obtain energy (biofuels).

An important fact is that in 1940 the world population was about **2.2 billion people**, and in 2021, the world population was around **7.8 billion people**.

This is the scenario in which we find ourselves. Geography is no longer an insurmountable barrier. Technology makes it easier for us to approach and exchange. The cultural defence of protection of the original food systems begins. UNESCO awards labels to different cultural food heritages (Medina 2016).

To summarize it, we could say that the symbol could be McDonald's. We can find brands with a global presence in any country. At this stage, globalization and the global vision of the food system are in full swing. We refer both to the trade of products and to the exchange of cuisines and the combination of cultures (Contreras 2016).

If we dare to predict the future from cultural traditions and cuisines, we could focus on two scenarios:

(a) A food system with homogeneous and globalized cuisine and food products and local cultures with a testimonial and tourist projection or
(b) A scenario in which the different gastronomic and culinary cultures prevail with their characteristics and personality and in turn coexist with a more global food system.

This possibility may be the prevalent one, taking into account that sustainability will force a reduction in food globality. We will have to see this evolution.

However, before analysing the cultural aspects through the cuisine, we must ensure adequate and sufficient sustainable production in balance with the planet and the population, to achieve the goal of Zero Hunger. We can make some comments related to the complexity of the food system.

The Complexity of the Global Food System

The first objective of any biological system is to survive, and the human species is no exception. The necessary energy which we obtain from food comes almost exclusively from photosynthesis, from agriculture, grazing livestock and deep-sea fishing.

If we focus on some aspects of the complexity of the food system and how they are affected by the geographical structure of the world, the challenge is that we are heading towards a universal global food system, whose population will continue to grow to exceed **10 billion people** by the end of this century, that can call into question food security. Maybe we have to change our habits of consumption.

Today's agriculture, with its light and shade, is capable of feeding a world population of more than **7 billion people**, but we have a global problem of accessibility to food. Maintaining the balance in the global food system described in this chapter is key to achieving the Zero Hunger Goal.

Vaclav Smil, "Feeding the world. A challenge for the twenty-first century" (2003), states: "The only way to maintain **10 billion people** (which is a plausible prospect in the medium term) with a traditional farming system based exclusively on recycling organic matter and legume rotations would represent doubling or even tripling the amount of land that is cultivated today".

Today, **the problem is more the lack of economic resources**, than of food and the destabilization of prices which are the gateway to new legions of the hungry. It has been estimated that if there is a 20% rise in real food prices in 2025, the world's undernourished population would increase by 440 million people (Senauer and Sur 2001).

The **groups most exposed to malnutrition** (Fig. 4) are those that have moved away from the classic agrarian systems (De Castro 2012) based on diversity and self-sufficiency and, for this reason, urban areas are the most sensitive population centres, but also the environments and areas dependent on the monoculture agriculture for export. Obviously, it is not about idealizing "primitive" agriculture, but it must be

Fig. 4 The key concepts to understand malnutrition in our world are poverty, food dependency, urban population and price instability. Image Triptolemos Foundation©

considered that some models of "unbridled" development involve weaknesses if forms of regulation and guarantee of supply are not foreseen for impoverished countries and populations. The key concepts to understand malnutrition in our world are poverty, food dependency, urban population and price instability (Reguant 2009).

Food production per unit area has remained, in relative terms, more or less constant since the origin of agriculture until a little over one or two centuries ago, with the agricultural area increasing at practically the same rate as the population. Globally, if we compare the increase in **world population in relation to the increase in agricultural production** in the last 60 years, the population has multiplied by almost 2.5, while the production of cereals, as well as many other crops, by 4. In the last 50 years, it has gone from requiring 1 ha of agricultural crops to feed one person for a year to only 0.32. It is estimated that 50% of all these advances in production are due to science and technology.

At the crossroads of climate change, the decisions we make today will greatly determine the sustainability and food security of our continent in the future (Peyraud and MacLeod 2020).

Climate change has and will have influence on food production and health. The question is whether there is a shortage of food or if there will be in the near future (Reguant 2009), since despite the fact that hunger and malnutrition affect some 900 million people, there has been food availability at all times in order, on paper, to supply the total demand (EEA 2021). In any case, it is indicated that the "solvent demand" is considered, that is, that of the population with sufficient purchasing power to buy food, since the "real demand", which includes that of those who lack economic resources, goes further (Colomer et al. 2021).

The United Nations considers climate change as "a multiplier value of threats, as it exacerbates those caused by violence, persistent poverty or poor resource management". Climate change, the overpopulation of certain geographical areas or the malnutrition that many countries will suffer are presented as true pandemics of the twenty-first century. We have to add that according to the **United Nations World Food Programme**, the incidence of COVID-19 could almost double the number of people suffering from acute hunger worldwide (Eurostat 2021).

The **European Green Deal Strategy** (Fig. 5) can contribute to achieve the 17 Sustainable Development Goals. We refer to climate change as a factor that conditions the future of the territories, the development of the food system and food safety. In this sense, the European Commission has launched the Green Deal and the "Farm to Fork" strategy (European Commission 2019). The European Green Deal establishes the way to make Europe the first climate-neutral continent by 2050. It defines a new strategy for sustainable and inclusive growth to boost the economy, improve people's health and quality of life, take care of nature and leave no one behind. The **Farm to Fork Strategy** (European Commission 2020) is an essential element of the Green Deal. It comprehensively addresses the challenges of sustainable food systems and recognizes the inextricable links between healthy people, healthy societies and a healthy planet. The strategy is also a fundamental component of the Commission's agenda to achieve the 17 Sustainable Development Goals (SDGs) of the United Nations, and we place special emphasis on the challenge of achieving compliance with SDG 2, **the challenge of zero hunger**.

The strategies adopted by the EU to reduce the impact of agriculture on the environment impose a drastic reduction in the use of fertilizers, antimicrobial agents and pesticides, predictably accompanied by a decrease in the total cultivated area. Regardless of the impact that these measures end up having on global sustainability, the truth is that the "Green Deal" strategy will put great pressure on our agricultural production systems (Beckman et al. 2020).

The pressing reality is that, today, our agriculture is not ready for this change. To adapt to the new situation, we need crops that produce more with less input (Bernard and Lux 2017). We need to develop new and better comprehensive strategies for pest control, adapt our varieties to climate change and we must learn to acquire and

Fig. 5 The European green deal (*Source* EU website)

process better the data that is generated from farm to fork (UE strategy) to optimize the management of the process as a whole (Ricard 2016). As has been shown on other occasions throughout history, a transformation of these dimensions can only be brought to fruition if it is accompanied by a great boost to research, development and innovation.

Also, we should keep in mind that "there is no end to chronic hunger, the cost of nutritional deficits or the challenge of unhealthy diets without bold actions to change. There is no route to better livelihoods and greater gender equality unless we start to pay farmers and farmworkers fairly" (UN special envoy Agnes Kalibata 2021).

Referring to **food waste**, this is a great challenge to the fight for zero hunger and it affects all stages from production to consumption (Conrad et al. 2018). According to the FAO, in the EU a third of food waste occurs once food has reached our homes. Consumers, producers and distributors must design strategies to avoid them.

However, the other two thirds of food waste is produced because either we do not have the appropriate varieties, or we do not use them, or because crops are produced under adverse conditions derived from climate change. Harvests also decline due to the action of pests or attack by pathogens such as viruses, fungi and bacteria that, in turn, are also developing emerging diseases due to climate change and the mobility of people and goods. We have to bear in mind that we only have agricultural products that have not been devastated by pests. Losses occur during post-harvest, food storage or transportation or as a consequence of unintelligent production strategies that lead to the disposal of crops because their marketing value does not compensate for production costs (Stuart 2009).

The current **international human rights** system was born in 1948, when the United Nations General Assembly approved the Universal Declaration of Human Rights, an essential element in a modern state and linked to the availability of food, and FAO proclaimed the food rights of man (Barcelona 1992).

The **right to food** is a universal human right recognized by international law, which protects the right of all people to obtain food, either by their own production or by the means necessary for its acquisition.

The World Food and Agriculture Organization (FAO) urges us to achieve food security, understood as the situation in which everybody, at all times, has physical and economic access to enough food, safe and nutritious, to satisfy their nutritional needs and preferences, in order to lead an active and healthy life (FAO 2014).

Feeding a Growing Population in Balance with the SDGs

The world population is growing with the tendency to concentrate in **urban areas**. The right to adequate food for the entire population represents a major challenge in the current context.

Over the next 30 years, **the lack of access to food and water** will increase if there is no urgent global cooperation, and if the issues are not approached from a global vision of the system.

Directly or indirectly, humanity provides itself with most of its food through agriculture, as well as a very important proportion of its clothing and medicinal, industrial and energy products. Agricultural progress has allowed us to continually overcome the demographic challenges we have faced, and we will undoubtedly successfully overcome the planetary challenges of the coming decades. Megan Clark, former director of the CSIRO (Australian National Research Agency), is credited with the phrase "**In the next 50 years we will have to produce as much food as we have in the previous ten thousand**", which reflects the food challenge we face, in order to overcome which a new agriculture is being developed, incorporating new tools from information technologies, data science, artificial intelligence, terrestrial and spatial sensors and all molecular tools, particularly genomic, available to the more conventional techniques (Blackstock et al. 2020).

For the geopolitics of the twenty-first century, water is destined to be what oil was for the twentieth century, so it will become the subject of great conflicts. Competition for limited water resources is one of the main concerns for the next decades. **Agriculture needs large amounts of water.**

Irrigation is the basis for food production faced with the challenge of a growing world population (Fig. 6), despite the fact that there are currently more than 800 million inhabitants below the threshold of malnutrition. Unlike oil, water has been the subject of an eternal debate on whether it should be luxury goods or a social goods accessible to all. Irrigation multiplies wealth generation by 4.8 and job creation by 4.5, compared to dry land.

Irrigated agriculture produces up to six times more than rainfed agriculture. One hectare of intensive irrigation can produce the equivalent of 40 hectares of dry land. For example, in Spain, 13 of the 15 provinces that have lost the most population in

Fig. 6 Irrigation is the basis for food production faced with the challenge of a growing world population (Image: Triptolemos Foundation)©

Fig. 7 Irrigated agriculture produces up to six times more than rainfed agriculture (Image: Triptolemos Foundation)©

the last 10 years are the ones with the smallest irrigated area (Fig. 7), and among the provinces that maintain or grow in population, there are many that have the highest proportions of irrigated crops. In addition to absorbing CO_2, irrigation contributes oxygen to the atmosphere through the photosynthesis of the vegetation cover and also contributes to reducing erosion and desertification, two dangerous consequences that could be accentuated by climate change.

Ageing is more pressing in rainfed areas, and the distribution of the **male–female population** in irrigated areas is more balanced, given that these crops contribute to reducing migration, especially of women from the rural world.

The strategic aspect of water is reflected in the fact that water begins to trade on the stock market. At the moment, it only affects the area of California, in the United States, meaning that the price of water in California fluctuates depending on the evolution of the Wall Street futures market. The demand for water is "practically inelastic". The amount required hardly varies because it is an indispensable resource in our daily life. Drinking water is limited, and in a world with almost 8000 million people, what is clear is that an effort must be made to rationalize its use and consumption and **move towards a new model of production and consumption** different from the current one (European Commission 2019). Since 2010, access to drinking water is recognized as a "basic human right" by the United Nations.

A study by the Institute for Economics and Peace (Institute for Economics and Peace. Ecological Threat Report 2021) based in Australia warns of the massive displacement of 1.2 billion people worldwide by 2050 and estimates that 2.6 billion people in the world are currently suffering from **water stress**, a figure which is forecast to increase to 5.4 billion people by 2040. It is estimated that about a fifth of the world's countries will experience water scarcity in 2040, and consequently, **hunger and migrations will increase**.

Water is the source of life. Its importance is evident in several of the SDGs. Figure 2 shows the relevance of the coordination between the different SDGs, and in this case the strategic importance of water that determines the objective of several of the SDGs, in a special 2.

There is a consensus on the potential of new information technologies, data science, artificial intelligence, terrestrial and space sensors and available molecular technologies, particularly genomics. All these technologies in an integrated way should reduce the production costs of healthier agricultural and livestock products, moderating the expenditure on inputs, as well as limiting the presence of pollutants and residues in the environment and in the final products, translating into greater food safety. We must rely on unfettered science and technology to meet the food challenges of the twenty-first century.

In order to achieve the ODS 2 (Clotet et al. 2010), the EU is a global agricultural power, but with very diverse cultural, geographical and climatic realities. For the sustainability of agriculture, farmers must have the freedom to choose the tools and practices that are best suited to their specific needs and agricultural environments according to proven science. Excluding tools that can contribute to this is dangerous (Pretty and Bharucha 2014).

As a result of **agricultural advances**, we have never before had access to so much food and quality in human history (Fig. 8). In the agricultural field, the quotation of Jonathan Swift (1667–1745) that appears in Gulliver's Travels is frequently mentioned: "….whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together…".

Sustainable Global Food System and SDGs for Zero Hunger

The preceding paragraphs outline the path that humanity has travelled, overcoming difficulties of various kinds and with a constant struggle for its survival. This complex environment, if we refer to SDG 2 Zero Hunger, requires a global approach and a balance of multiple factors (Beltrán et al. 2021).

Only from the approach of a sustainable global food system (Clotet et al. 2013), which considers the availability of food, the economy, policies and culture, all of them interrelated and in balance, with the support of science, technology, responsible business activity and consumption, can we face the food challenges of the XXI century with a minimum guarantee aligned with the Sustainable Development Goals (SDG) and try to achieve the Zero Hunger.

From the Triptolemos Foundation, the **Sustainable Global Food System** is focused on 4 basic main axes or macro-areas (Fig. 9): availability, economy, politics and culture and the multiple interrelationships between them. All of them are interrelated and have to be in balance for the proper functioning of the Sustainable Global Food System.

These 4 axes or macro-areas are aligned with the 17 United Nations Sustainable Development Goals (Colomer et al. 2016).

Fig. 8 The EU is a global agricultural power, but with very diverse cultural, geographical and climatic realities, Triptolemos Foundation©

- In the **availability and accessibility axis**, all the elements that ensure that there is enough food for adequate nutrition for everybody in balance with the planet are considered (land, water, supplies, climate change, agriculture, food transformation, food waste, nutrition…).
- In the **Economy axis**, the set of all economic activity from the field to the table is included. It is the total food economy concept. It is considered the economy of the citizen that indicates their ability, in their environment, to acquire food at affordable prices. This concept that has a very close relationship not only with the global aspects of the economy (macro and microeconomics), but also with aspects of the policy and cultural axes considered.
- In the **Policy axis**, all activity that society as a political entity generates around the food system is considered. It is based on a fundamental right, the right to life.

Fig. 9 Definition by Triptolemos Foundation of the sustainable global food system (Colomer et al. 2016) (*Source* Triptolemos Foundation)

The availability and safety of food must be guaranteed (food security and food safety). Here, we look at food policies, regulations, legislation and human rights.

- The **Culture axis** considers knowledge, training and social behaviour (sociology, anthropology, consumer trends, cultural and religious taboos …). Eating goes beyond scientific bases; it has important emotional implications (beliefs, pleasure, social aspects …).

The necessary balance between the 4 axes of the food system model described coincides with the necessary balance between the 17 SDGs set by the United Nations. They are all important and interrelated. Any maximalization of a variable unbalances the system and generates dysfunctions and problems.

The **growth of humanity** must be harmonious and sustainable within an ethical framework to achieve the 17 SGDs (Fig. 2). This will not be achieved if the same evolution does not occur simultaneously in the global food system, where all the vectors that make up the food system evolve proportionally and are in balance. At present, one of the problems is that solutions are not always sought from the point of view of a sustainable global food system. If only one of the parameters of the system is maximized, either in a self-interested or ignorant way, the imbalance in the system inevitably increases (Fig. 10).

By describing in general terms how the Triptolemos Foundation interprets the global food system, it will be possible to have a better understanding not only all the importance of the SDG 2 objective but also the relationship of food with the rest of the SDGs and geography, all of them are interrelated.

It will be difficult to achieve SDG 2, Zero Hunger, and refer to global food security, if simultaneously we do not have enough food for an adequate diet for the needs of each person, at the same time that we have access to it with a guaranteed distribution

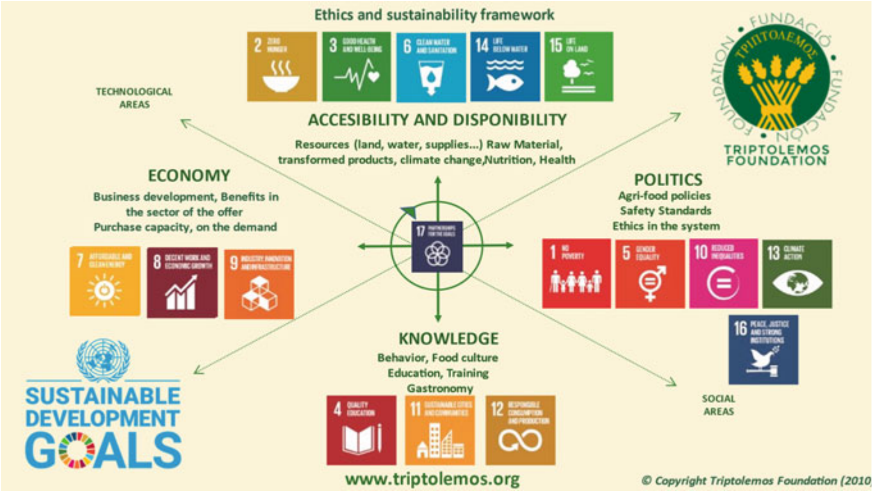

Fig. 10 The SDGs and the challenges of the sustainable global food systems. The 4 axes are interrelated and have to be in balance for the proper functioning of the sustainable global food systems. (*Source* Triptolemos Foundation)

and, most important, the population has sufficient financial resources to buy this food.

A Quantitative Model of Approximation to the SDGs. Zero Hunger

Triptolemos Foundation has developed a quantitative model around the **Global Food System.** The model based on defined variables allows prospecting and comparisons between food systems in different countries and territories, with the Trademark Registry, **Triptolemos Index of the Global Food System (ITRIn).** The Triptolemos Global Food System model allows the quantitative analysis (Clotet et al. 2018), diagnosis and prospective modelling of the Global Food System, with quantitative variables defined in very different areas (agricultural production and climate change, consumption trends, prediction of markets and sectors, social behaviour of both citizens and governments, availability of food, economy, among others), countries and territories and their business application. **The approach of the model contributes to the foresight and quantification of the SDGs**.

Delving into one of the most important aspects, such as agriculture (availability and accessibility axis), an important but not the only factor to achieve SDG 2 (**zero hunger**) since its achievement is linked to economic aspects of the population (SDGs 3, 4 and 8 among others), as shown in Fig. 2.

We have the challenge of adequately **feeding a growing population** in balance with the economic and social sustainability of the planet and in an unquestionable scenario of climate change. The current challenge of agriculture is to ensure sustainability, being aware that in the next half century, we have to produce as much as in the previous ten thousand years, at the same time, having to worry about improving crop resilience, in an unquestionable scenario of climate change.

Population, resources, strategies, ethics …. Geography influences all this and conditions the concept of globalization. Sustainability in a humanly ethical context must be the solution, not only for the planet but for the society that is its tenant. It is important, for the growth of humanity to be harmonious and sustainable within an ethical framework, that all the vectors that make up the food system evolve proportionally and are in balance, and all of them aligned with the 17 SGDs.

In the opinion of Triptolemos Foundation, the food challenges of the XXI century can only be faced with a minimum guarantee through a sustainable and ethical global food system, which considers the availability of food, the economic, policies, behaviour and culture, all of them interrelated and in balance, with the support of science, technology and responsible business activity. If only one of the parameters of the system is maximized, either in a self-interested or ignorant way, the imbalance in the system inevitably increases and this distances us from achieving Goal 2, Zero Hunger.

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SDG 3. Ensure Healthy Lives and Promote Well-Being for All at All Ages

Exploring Health and Well-Being in a European Context

Ruth McManus

Abstract The third Sustainable Development Goal sets out to ensure healthy lives and promote well-being for all at all ages. This will be measured in terms of 13 targets, many of which are direct life and death issues. For example, specific targets relate to reduction of maternal, neonatal and under-5 mortality, addressing communicable and non-communicable diseases, and reducing other causes of death including substance abuse (drugs, alcohol, tobacco) and road traffic accidents. A focus on improved quality of life is also seen in the target of ensuring universal access to sexual and reproductive healthcare services, and providing access to quality essential healthcare and safe, effective, quality and affordable essential medicines and vaccines for all. This chapter will begin with an overview of SDG3, outlining the 13 targets and associated indicators. It will then turn to an evaluation of how well we are doing in relation to this goal, drawing on data from 2015, when the SDGs were instigated, the current status of the indicators, and the latest predictions for the 2030 end date of the SDGs. An international and regional comparative perspective will be used in order to set the context. While the perception may be that Europe is ahead of other regions in achieving targets related to SDG3, there are also areas where the region is lagging behind. As we look within Europe, it will also become clear that there are distinct variations at a national level, and that specific challenges remain. Some consideration will be given to the fact that some of the progress made in many health areas before the COVID-19 pandemic, including improving maternal and children health, increasing immunisation coverage, and reducing communicable diseases, has now halted or even been reversed. Disruptions to essential health services, even within relatively wealthy regions such as Europe, have affected services mental, neurological and substance use disorders; HIV and hepatitis B and C; cancer screening and services for other non-communicable diseases. Moving beyond the statistical data, the chapter then turns to consider some of the questions arising out of SDG3 within the European context. Across the continent, the population structure is changing. Two forms of demographic ageing are being experienced. On the one hand, 'bottom up' ageing is being seen as birth rates decline and the younger age cohorts of the population

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_3

pyramid become smaller than the older generations. On the other hand, 'top down' ageing is also evident as life expectancy increases. While European governments are attempting to address this issue, one of the consequences of more people living longer is that there is an increase in a range of non-communicable diseases. Furthermore, as we appear to have entered the late stages of epidemiological transition, health issues associated with degenerative diseases, lifestyle and emerging diseases are on the rise. In its final section, the chapter will look outward from the European perspective, considering responsibilities and ethical issues relating to overseas aid, globalisation and policies which impact on the capacity of other regions and nations to achieve the targets set out by SDG3.

Keywords SDG3 · Population · Demographic change · Health · Well-being · Europe

Introduction

About SDG3 and its Targets

The third Sustainable Development Goal sets out to ensure healthy lives and promote well-being for all at all ages. This will be measured in terms of 13 targets, many of which are direct life and death issues. For example, specific targets relate to reduction of maternal, neonatal and under 5-year-old child mortality, addressing communicable and non-communicable diseases, and reducing other causes of death including substance abuse (drugs, alcohol, tobacco) and road traffic accidents. A focus on improved quality of life is also seen in the target of ensuring universal access to sexual and reproductive healthcare services, and providing access to quality essential healthcare and safe, effective, quality and affordable essential medicines and vaccines for all. Readers interested in a brief overview of SDG3 might find this link helpful, as it incorporates the impacts of COVID-19, discusses the concept of equity in health and makes suggestions as to what individuals can do: https://www.youtube.com/watch?v=ZVqSC_hN2lk.

Table 1 gives all 13 targets and associated indicators. Note that the indicator framework is refined annually and was reviewed comprehensively in March 2020. The indicators listed in Table 1 have incorporated refinements up to and including March 2021.

Exploring the Data on SDG3

SDG3 is the largest goal in the entire 2030 Agenda, covering a large range of topics related to preventing and treating sickness and prolonging life expectancy. This section evaluates progress in relation to the majority of the 13 targets and associated

Table 1 Targets and associated indicators

	Target description	Indicators
3.1	By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births	3.1.1 Maternal mortality ratio 3.1.2 Proportion of births attended by skilled health personnel
3.2	By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under 5 mortality to at least as low as 25 per 1000 live births	3.2.1 Under 5 mortality rate 3.2.2 Neonatal mortality rate
3.3	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases	3.3.1 Number of new HIV infections per 1000 uninfected population, by sex, age and key populations 3.3.2 Tuberculosis incidence per 100,000 population 3.3.3 Malaria incidence per 1000 population 3.3.4 Hepatitis B incidence per 100,000 population 3.3.5 Number of people requiring interventions against neglected tropical diseases
3.4	By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being	3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease 3.4.2 Suicide mortality rate
3.5	Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders 3.5.2 Alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol
3.6	By 2020, halve the number of global deaths and injuries from road traffic accidents	3.6.1 Death rate due to road traffic injuries
3.7	By 2030, ensure universal access to sexual and reproductive healthcare services, including for family planning, information and education and the integration of reproductive health into national strategies and programmes	3.7.1 Proportion of women of reproductive age (aged 15–49 years) who have their need for family planning satisfied with modern methods 3.7.2 Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1000 women in that age group
3.8	Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all	3.8.1 Coverage of essential health services 3.8.2 Proportion of population with large household expenditures on health as a share of total household expenditure or income

(continued)

Table 1 (continued)

	Target description	Indicators
3.9	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3.9.1 Mortality rate attributed to household and ambient air pollution 3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services) 3.9.3 Mortality rate attributed to unintentional poisoning
3A	Strengthen the implementation of the World Health Organisation Framework Convention on Tobacco Control in all countries, as appropriate	3.a.1 Age-standardised prevalence of current tobacco use among persons aged 15 years and older
3B	Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement[1] and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all	3.b.1 Proportion of the target population covered by all vaccines included in their national programme 3.b.2 Total net official development assistance to medical research and basic health sectors 3.b.3 Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis
3C	Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States	3.c.1 Health worker density and distribution
3D	Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	3.d.1 International Health Regulations (IHR) capacity and health emergency preparedness 3.d.2 Percentage of bloodstream infections due to selected antimicrobial-resistant organisms

Source https://unstats.un.org/sdgs/indicators/indicators-list/. Accessed 5 October 2021

indicators of SDG3, drawing on data from 2015, when the SDGs were instigated and the current status of the indicators. An international and regional comparative perspective is used. While the perception may be that Europe is ahead of other regions

[1] The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) is an international legal agreement between all the member nations of the World Trade Organisation, which is discussed later in this chapter.

in achieving targets related to SDG3, there are also areas where the region is lagging behind. As we look within Europe, it will also become clear that there are distinct variations at a national level, and that specific challenges remain.[2]

Although 2015 is used as the starting point for the SDGs in the data presented here, it should be recalled that the SDGs were preceded by the Millennium Development Goals, which ran from 2000 to 2015. At least three of these earlier MDGs specifically related to health and well-being, focusing on reduction in child mortality, improving maternal health and combatting HIV/AIDS, malaria and other diseases. Thus, it could be argued that a targeted battle against certain elements within SDG3 was already underway for 15 years before the formal initiation of the SDGs. Even earlier, in the 1992 *Agenda 21*, the action plan which arose from the Earth Summit in Rio de Janeiro, devoted Chapter 6 to 'protecting and promoting human health'. The good health and well-being goals are clearly explained in this 3 min video: https://www.youtube.com/watch?v=HN9Gz7rCFo4.

Target 3.1: Reduce Maternal Mortality

Globally, some 451,000 women and girls died from complications of pregnancy and childbirth in 2000. Target 3.1 of the SDGs is to reduce maternal mortality. Two indicators, maternal mortality ratio and skilled birth attendance, are used to measure progress. Globally, maternal mortality[3] declined by 38% between 2000 and 2017 (the most recent date for which data is available). This represents a fall from 342 deaths to 211 deaths per 100,000 live births, according to UN inter-agency estimates. While this is a significant achievement, it still means that over 800 women die each day from complications in pregnancy and childbirth. The goal is to reduce the maternal mortality ratio to less than 70 per 100,000 live births, with no country having more than 140 maternal deaths per 100,000 live births[4] A map of this indicator for Europe shows that already in 2015 this minimum target had been reached by all European countries.

Table 2 gives the changing maternal mortality rates for the world and for selected regions. Europe has the lowest maternal mortality rates in the world, averaging just 5 deaths per 100,000 live births. This is in sharp contrast with Sub-Saharan Africa, the region with the highest maternal mortality rates, at 534 per 100,000 live births in 2017, representing over two-thirds of all maternal deaths worldwide. The countries with the lowest rates, just 2 per 100,000, in Italy, Poland, Belarus and Norway, contrast with highs of 1150, 1140 and 1120 per 100,000 in South Sudan, Chad and Sierra Leone, respectively. Almost all of these maternal deaths are preventable, particularly if births are attended by skilled health personnel.

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[2] See https://sdg-tracker.org/good-health#targets.

[3] The maternal mortality ratio is defined as the number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births.

[4] https://data.unicef.org/topic/maternal-health/maternal-mortality/.

Table 2 Maternal mortality ratio for world and selected regions, 2000, 2015, 2017

Region	2000	2015	2017
World	342	219	211
North America	12	17	18
Europe and Central Asia	27	14	12
Middle East and North Africa	106	59	62
Latin America and Caribbean	96	77	74
East Asia and Pacific	114	73	69
South Asia	395	179	163
Sub-Saharan Africa	870	557	534

Source https://sdg-tracker.org/good-health#targets drawing on data from World Development Indicators, World Bank (2021), which in turn is drawn from the World Health Organisation (2019) Trends in Maternal Mortality. The regions are combined as indicated above, so that Europe and Central Asia are listed together

Target 3.2: End All Preventable Deaths Under 5 years of Age

The second target within SDG3 is to end preventable deaths of newborns and children under-five years of age. As with maternal mortality, European countries had already achieved the targets set for both indicators by 2015. The under-five mortality rate[5] varies significantly between different parts of the world, as is clear from Table 3. By 2015, in the European Union, fewer than 4 babies out of every 1000 live births would die by the age of five, compared to over 85 babies born in Sub-Saharan Africa. As of 2019, the highest under-five mortality rates in the world are in Somalia (118.3), Nigeria (116.9), Chad (113.5), Sierra Leone (111.9) and Central African Republic (106.6), contrasting with the lowest rates in San Marino (1.8), Iceland (2.0), Estonia, Finland, Norway and Slovenia (2.3). Some of the greatest relative changes between 2015 and 2019 also occurred in Europe, with drops in Estonia (−26%), Lithuania (−27%), Russia (−29%), Montenegro (−35%) and North Macedonia (−40%). However, it is worth noting that some increases have been noted in European countries, albeit from a low base. Thus, the under-five mortality rate in France rose by 2% to 4.3 in 2019, while rates also rose by 2% in Belgium (to 4.2) and the Netherlands (to 4.1), though these rates are still well below the SDG target of 25 per 1000 live births.

Neonatal mortality, which refers to deaths of newborns within their first month of life, is extremely low in Europe (2.32 deaths per 1000 live births in the EU in 2019), again in stark contrast with Sub-Saharan Africa (27.6) and South Asia (24.9).

[5] Under-five mortality rate is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.

Table 3 Under 5 mortality rate for world and selected regions, 2000, 2015, 2019

Region	2000	2015	2019
World	75.8	42.6	37.7
North America	8.3	6.7	6.3
Europe and Central Asia	21.4	9.7	7.9
Middle East and North Africa	42.3	24.0	21.9
Latin America and Caribbean	33.1	18.1	16.6
East Asia and Pacific	39.4	17.0	14.3
South Asia	93.4	48.8	40.3
Sub-Saharan Africa	150.6	85.7	75.6

Source https://sdg-tracker.org/good-health#targets drawing on data from World Development Indicators, World Bank (2022), which in turn is drawn from the UN Inter-agency Group for Child Mortality Estimation. http://data.worldbank.org/data-catalog/world-development-indicators

Target 3.3: Fight Communicable Diseases

The third target of SDG3 is to fight communicable (infectious) diseases, specifically to end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases by 2030. In this case, the data is somewhat less clear cut than for maternal and child mortality. A number of indicators fall within this category. The first relating to HIV/AIDS can be measured by looking at the number of new cases of HIV per 1000 uninfected people aged 15 to 49 years of age. Globally, this rate has fallen by 54% between 2000 and 2019. However, Europe has seen its rate grow by 71%, with particularly strong growth in Serbia (+400%), Montenegro (+250%), Greece (+117%) and Croatia (+100%), representing a worrying trend. By contrast, rates of tuberculosis are stable or falling in European countries, with the exception of Sweden which saw a small increase of 2% between 2000 and 2019, but from a very low base. The World Health Organisation's Stop TB Partnership has set a target (not specifically related to the SDGs) of reducing national incidence of TB to fewer than 20 cases per 100,000 by 2030. Within Europe, there appears to be an east–west divide in relation to tuberculosis incidence (i.e. cases of tuberculosis per 100,000 population) with 2019 data showing the highest incidence occurring in Moldova (80), Ukraine (77), Romania (66), Russia (50), Lithuania (42), Belarus (29), Bosnia and Herzegovina (27), Latvia (26) and Bulgaria (21). In Western Europe, typical figures are under 10 per 100,000, such as Norway (3.3), Netherlands (5.0), Denmark (5.2), Sweden (5.5), Ireland (5.8), Austria and Italy (6.0) .

Malaria, the third specific disease discussed under the third target, is most prevalent in Africa. Nine out of every ten deaths from malaria in 2015 was in Africa; although there has been significant progress in reducing malaria deaths, in 2017, the World Health Organisation (WHO) warned that the fight against malaria had reached a crossroads.[6] The World Malaria Report 2020 noted that global gains in combatting malaria had levelled off in recent years. While malaria is a disease associated with tropical regions in the present day, prior to about 1900 malaria posed a risk across more than half of the world's land surface. Historically, malaria was prevalent in Europe and in North America. Oliver Cromwell (1599–1658) contracted malaria in Ireland, while poet Friedrich Schiller (1759–1805) contracted it in Mannheim, Germany. Since then the disease has been eliminated not only there, but also in East Asia and Australia and in many parts in the Caribbean, South America and Africa (Hay et al. 2004). Potentially, climate change could result in a return of malaria to Europe, although current research suggests that this is unlikely.[7]

The two remaining indicators of this target relate to incidence of Hepatitis B and tackling neglected tropical diseases, neither of which will be covered in this chapter.

Target 3.4: Reduce Mortality from Non-communicable Diseases and Promote Mental Health

Unlike communicable diseases, where Europe is in a relatively strong position with low incidence rates, mortality rates from non-communicable diseases and suicide are a cause for concern in the region. Table 4 illustrates the mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease[8] Cardiovascular disease (a blanket term for diseases relating to the heart and blood vessels, including coronary artery disease and stroke) is the number one cause of death globally, followed by cancer. In wealthy countries, non-communicable diseases (i.e. those which are not directly passed from one individual to another) account for the majority of deaths. The goal is to reduce premature mortality from NCDs by one-third in all countries. Between 2015 and 2019, the countries of the European Union experienced a drop of 7% in this rate, but it is unclear whether the downward trend will be sufficient to achieve the SDG target. Many non-communicable diseases are associated with lifestyle choices, including diet/obesity, tobacco use, alcohol consumption and lack of exercise, although other 'degenerative' diseases are associated with physical ageing of the body, and become more common as people live longer. The mortality rate for NCDs is defined as the percent of 30-year-old-people who would die before their 70th birthday from one of the following: cardiovascular disease, cancer, diabetes

[6] World Malaria Report 2020, available at https://cdn.who.int/media/docs/default-source/malaria/world-malaria-reports/world-malaria-report-2020-briefing-kit-eng.pdf?sfvrsn=eda98467_18&download=true.

[7] See https://www.un.org/en/chronicle/article/climate-change-and-malaria-complex-relationship.

[8] This is defined as the percent of 30-year-old-people who would die before their 70th birthday from any of cardiovascular disease, cancer, diabetes, or chronic respiratory disease, assuming that they would experience current mortality rates at every age and would not die from any other cause of death (e.g. injuries or HIV/AIDS).

Table 4 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease for world and selected regions, 2000, 2015, 2019

Region	2000	2015	2019
World	22.9	19.0	18.3
North America	17.7	13.5	13.2
Europe and Central Asia	23.4	17.5	16.4
Middle East and North Africa	23.9	21.2	20.2
Latin America and Caribbean	18.5	15.4	14.8
East Asia and Pacific	22.2	17.6	16.9
South Asia	25.7	23.0	22.4
Sub-Saharan Africa	26.4	22.5	21.3

Source https://sdg-tracker.org/good-health#targets drawing on data from World Development Indicators, World Bank (2022), which in turn is drawn from the World Health Organisation Global Health Observatory Data Repository at https://datacatalog.worldbank.org/search/dataset/0037712/World-Development-Indicators

or chronic respiratory disease[9] For the European Union as a whole this figure is 12.35%, compared with a world average of 18.27%. Within Europe, a high of 24.2% in Bulgaria contrasts with 12.1% in Germany, 10.4% in Austria, 9.6% in Spain and just 7.9% in Switzerland. Non-communicable diseases are explained in under one minute in the following video: https://youtu.be/q0scBynXQL8.

The suicide mortality rate is a further indicator used in relation to target 3.4. Suicide is a leading cause of death, particularly among young people. Globally, the suicide mortality rate, defined as the number of deaths from suicide in one year measured per 100,000 individuals in a given population, was 9.17 in 2019. The rate for the European Union was above this world average, at 11.34, while many European countries exceed this level. Indeed, some of the highest suicide mortality rates in the world have been recorded in European countries, with Lithuania (26.1), Russia (25.1), Ukraine (21.6), Belarus (21.2), Montenegro (21) and Latvia (20.1) all exceeding a rate of 20 per 100,000. While this suggests higher rates are occurring in eastern parts of Europe, rates are also well above the global average in Belgium (18.3) and Austria (14.6), among others. The SDGs call for the promotion of mental health and well-being, rather than defining a specific target level of suicide reduction for this indicator. For more on this topic, see https://ourworldindata.org/suicide.

Target 3.5: Prevent and Treat Substance Abuse

Target 3.5 aims to strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol. Once again, Europe's

[9] Assuming that they would experience current mortality rates at every age and would not die from any other cause of death (e.g. injuries or HIV/AIDS).

record in relation to the indicator of alcohol consumption per capita suggests that there is a significant issue to be addressed. The available data for 2018 shows harmful use of alcohol, defined according to the national context as alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol. European countries dominate the league table, with all but three of the top 20 countries in terms of alcohol consumption being located in Europe. There is no distinct east–west or north–south divide. The highest consumption countries in Europe are Czechia (14.45 L), Lithuania (13.22 L), Luxembourg (12.94 L), Germany (12.91 L), Ireland (12.88 L), Latvia (12.77 L), Spain (12.72 L), Bulgaria (12.65 L) and France (12.33 L). Whereas the world average is 6.18 L and the least developed countries average at just 3.34 L per capita, the European Union average alcohol consumption is 11.44 L per capita.

Target 3.6: Reduce Road Injuries and Deaths

Unlike most SDG targets which are set for 2030, target 3.6 to reduce road injuries and deaths was set to be achieved for 2020 and was measured relative to 2010 levels as it was defined as part of the UN Decade of Action for Road Safety (2011–2020). The goal to halve mortality from road traffic accidents (including vehicle drivers, passengers, motorcyclists, cyclists and pedestrians) was not achieved by 2019. World data shows a drop of 6% between 2010 and 2019, while the reduction for the European region (WHO) was 18%. However, some European countries have made significant progress, including: Lithuania (− 44%), Moldova (− 42%), Russia (− 35%), Latvia (− 34%), Bulgaria (− 31%), Estonia (− 27%), Poland and Croatia (both 26%).

Target 3.7: Universal Access to Sexual and Reproductive Care, Family Planning and Education

According to target 3.7, by 2030 there should be universal access to sexual and reproductive healthcare services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes. In general, European countries perform well in terms of the indicators used. Indicator 3.7.1 considers the percentage of married women ages 15–49 years whose need for family planning is satisfied with modern methods of contraception. For most of Europe, no data is available, although the World Population Data Sheet 2021[10] suggests that across Europe an average of 59% of married women in the relevant age cohort are accessing modern methods of contraception, which is the same as for developed countries worldwide.

[10] World Population Data Sheet 2021, Population Reference Bureau: https://interactives.prb.org/2021-wpds/

The second indicator for this target looks at the adolescent birth rate, considering the birth rate per 1000 females aged 15–19 years. Compared to a world average of 41.58 births per 1000 women aged 15–19 years, the figure for the European Union is just 8.74, while some of the lowest rates in the world are seen in European countries including Switzerland (2.52), Slovenia (3.53) and the Netherlands (3.62). However, there are some European countries where adolescent birth rates are significantly higher, particularly Bulgaria (38.79) and Romania (34.86). Furthermore, in Slovakia (26.19) and Hungary (24.57), although the overall rate is lower, the trend between 2015 and 2019 was in an upward direction, with increases of 7% and 9%, respectively. This suggests that access to family planning and education needs to be improved.

Target 3.8: Achieve Universal Health Coverage

This target aims to achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all. The Universal Health Coverage (UHC) Index, which operates on a scale from 0 (worst) to 100 (optimal), is a metric use to track progress on this target. It combines information on 14 indicators measuring the coverage of essential services including reproductive, maternal, newborn and child health, infectious diseases, non-communicable diseases and service capacity and access, among the general and the most disadvantaged population. On average, Europe scores 79 on the index in 2019, the most recent year for which data is available. This compares with a world average score of 67. Countries with the highest UHC index are Canada (89), United Kingdom, Sweden, Australia, Switzerland, Norway and South Korea (all 87), contrasting markedly with the lowest scores in Somalia (27) and Chad (28).

Target 3.9: Reduce Illnesses and Deaths from Hazardous Chemicals and Pollution

Under target 3.9, the goal is to substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination. The death rate from ambient and household air pollution[11] varies from as low as 7 per 100,000 in Finland and 8 per 100,000 in Iceland, Norway, Canada and Sweden, to 315 deaths per 100,000 population in the Central African Republic.[12] The world

[11] The age-standardized annual number of deaths attributed to household and ambient air pollution per 100,000 people.

[12] Data is for 2019, drawn from the Global Burden of Disease Study (2019), while WASH data is drawn from the UN. Source: http://ghdx.healthdata.org/gbd-results-tool

average is 105 deaths per 100,000. Once again, Europe benefits from a relatively safe environment with excellent regulation of chemicals and pollution.

Indicator 3.9.2 is the mortality rate attributed to unsafe water, sanitation, and lack of hygiene, known as WASH factors. The world average in 2019 stood at 18.21 deaths per 100,000, with European countries having a rate of just 3.23 deaths per 100,000. Sub-Saharan Africa is the region which suffers the highest mortality rate in this category, as in Lesotho (108), Chad and Somalia (both 99) and Central African Republic (97).

Target 3.A: Implement the WHO Framework Convention on Tobacco Control

The goal of strengthening the implementation of the World Health Organisation Framework Convention on Tobacco Control in all countries, as appropriate, does not carry any specific targets. However, it is worth noting that some European countries have a relatively high rate of daily tobacco smokers, including Serbia (40.6% of the adult population), Greece (39.1%), Bulgaria (38.9%), Bosnia and Herzegovina (38.3%) and a further nine countries where over 30% of the adult population are daily smokers.[13] Tobacco use is directly linked to a number of non-communicable diseases and this lifestyle choice may help to explain some of the problems for European countries in achieving Target 3.4.

Target 3.B: Support Research, Development and Universal Access to Affordable Vaccines and Medicines

Target 3.b has become more relevant than ever in the light of the COVID-19 pandemic. The indicators used specifically focus on four vaccines (three-dose diphtheria, pertussis and tetanus (DPT3); second-dose measles vaccine recommended dose of pneumococcal conjugate vaccine (PCV3) and recommended dose of human papillomavirus vaccine). These vaccines are hugely important. Before the measles vaccine was introduced in 1963 and widespread vaccination became possible, major epidemics occurred approximately every 2–3 years and measles caused an estimated 2.6 million deaths each year. Complications from measles were once a leading cause of blindness. Despite the availability of a safe, effective vaccine, more than 140,000 people died from measles in 2018. Most of them were children under the age of five. The World Health Organisation estimates that measles vaccination prevented an estimated 23.2 million deaths between 2000 and 2018, making measles vaccine one of the best buys in public health. These 'facts in pictures' give a good overview:

[13] Data for 2018 is sourced from World Health Organization (WHO) Department of the Prevention of Noncommunicable Diseases; Secretariat of the WHO Framework Convention on Tobacco Control.

https://www.who.int/news-room/facts-in-pictures/detail/measles. Another indicator used in this category is the proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis. Learn more about the concept of universal health coverage in this video: https://www.youtube.com/watch?v=FlETZ202Ovg.

Target 3.C: Increase Health Financing and Support Health Workforce in Developing Countries

The UN goal is to substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing states. Health worker density, the size of the health workforce per 1000 people, based on the density of physicians, surgeons, nurses and midwives, dentistry and pharmaceutical personnel is an important indicator. European countries come close to the top of the global list for density of medical doctors, just after Cuba which tops the list at 8.42 physicians per 1000 people. The lowest physician density countries are Tanzania (0.01), Somalia (0.02) and Sierra Leone (0.03).[14] Recruitment of healthcare workers from the global south to the wealthier countries of the global north has helped to further impact the density of doctors, nurses and health scientists in the poorer parts of the world, despite in the USA in 2018, more than 2.6 million immigrants, including 314,000 refugees, were employed as healthcare workers. Immigrants make up 28% of physicians and 38% of home health aides in the USA.[15] These immigrant healthcare workers were also more likely to die from COVID-19 during the pandemic[16] A study of Britain's National Health Service (NHS) hospitals in 2019 found that 29% of doctors and 28% of nurses were non-British nationals.[17] Healthcare migration to OECD countries was interrupted during 2020 due to travel restrictions, despite an increasing demand for healthcare workers, see https://onesite.eiu.com/data-focus-healthcare-migration-slows/. Although it is expected that migration of healthcare workers will resume, developing countries are trying to reduce this medical brain-drain from further weakening their healthcare systems further.

[14] Data for 2018, sourced from http://data.worldbank.org/data-catalog/world-development-indicators.

[15] https://www.migrationpolicy.org/article/immigrant-health-care-workers-united-states-2018.

[16] https://www.theguardian.com/us-news/2020/aug/26/us-immigrant-doctors-dying-covid-19.

[17] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/internationalmigration/articles/internationalmigrationandthehealthcareworkforce/2019-08-15.

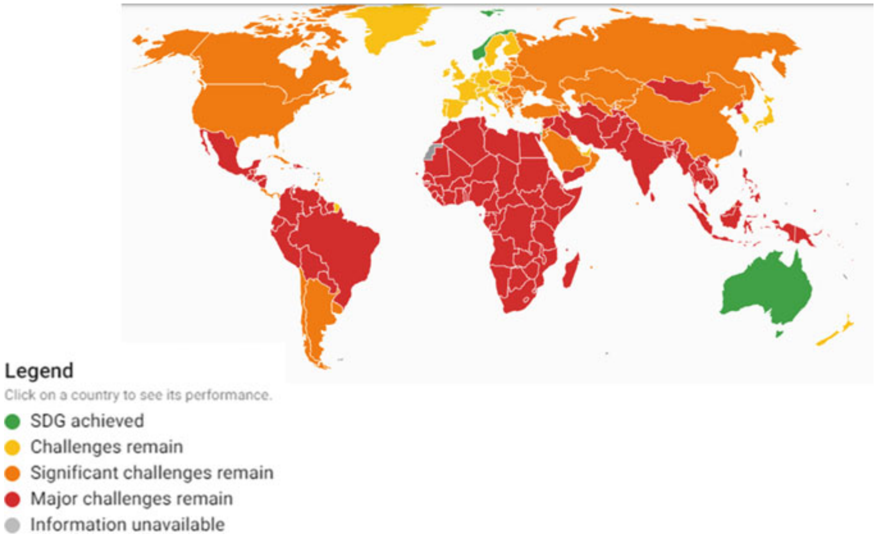

Fig. 1 Progress in relation to SDG3 (Sustainable development report 2021)

Overall Progress in Relation to SDG3

The UN's annual Sustainable Development Report presents progress towards meeting the goals. The trend assessment uses traffic light colours to measure progress from a baseline year to the most recent data point. While this is based on a limited number of indicators and on the information available as at June 2021, it nevertheless provides a useful overall impression of progress.[18] The 2021 world map for SDG3 (see Fig. 1) suggests that only two countries in the world, Norway and Australia, have achieved this goal. The majority of European countries fall into the next category 'challenges remain', although parts of Eastern Europe are classified as having 'significant challenges' remaining, e.g. Romania, Bulgaria and Greece.[19]

Even before the COVID-19 pandemic, the world was already off track in achieving its targets for 2030. The unfolding pandemic has magnified many deep-rooted problems in relation to structural inequalities, weak public health systems, inadequate health coverage and insufficient social protection. This is further discussed below.

[18] A baseline year of around 2015 or 2010 is used for the trend assessment. For most of the indicators, the latest available data are from 2019 to 2020; for a few indicators, the data are from 2017.

[19] See: https://dashboards.sdgindex.org/map/goals/SDG3.

COVID-19 Impacts on SDG3

At the time of writing in Autumn 2021, concerns were being raised that the progress made in relation to SDG3 had been halted, and in some cases even reversed, by the impact of the COVID-19 pandemic. Even before the COVID-19 outbreak, it was clear that progress on the global goals was uneven and that more focused attention was needed in most areas. Unfortunately, the disruption caused by the pandemic has had a negative impact in relation to the implementation of the goals, sometimes turning back progress. For example, the World Health Organisation's 2021 Global TB Report has shown that deaths from tuberculosis have increased for the first time in a decade as a direct result of the COVID-19 pandemic.[20] In its 2021 Sustainable Development Goals Report, the UN noted that 90% of countries were still reporting one or more disruptions to essential health services.[21] Furthermore, the interrelated nature of the goals has led to knock-on effects on the different Sustainable Development Goals as a result of the pandemic (Shulla et al. 2021). The UN has produced a short video highlighting some of the key aspects of SDG3 which have been impacted: https://www.youtube.com/watch?v=J5wZiVd-x4g.

Improving maternal and children health, increasing immunisation coverage and reducing communicable diseases has halted or even been reversed. Many of these are indirect health impacts of the pandemic, caused due to a range of factors including loss of income, poorer nutrition, disruption in seeking or receiving medical care. Early studies have attempted to quantify likely additional maternal deaths and child deaths, which could be very substantial. Disruption to family planning services is also expected to result in an increase in unintended pregnancies.

Interruptions to essential health services, even within relatively wealthy regions such as Europe, have affected services relating to mental, neurological and substance use disorders; HIV and hepatitis B and C; cancer screening and services for other non-communicable diseases. Impacts on healthcare workers, already in short supply in many regions, have been severe. The UN has argued that scaling up investment in universal health coverage (Target 3.8) is essential in the light of the pandemic. They have also pointed out that COVID-19 has highlighted the critical need for preparedness for health emergencies and may be a watershed moment both for such emergency readiness and for investment in critical twenty-first century public services.[22] Quoted in the UN's annual report on the SDGs for 2020, António Guterres, Secretary-General of the UN stressed that 'Everything we do during and after this crisis [COVID-19] must be with a strong focus on building more equal, inclusive and sustainable economies and societies that are more resilient in the face of pandemics, climate change, and the many other global challenges we face.'[23] Certainly the experience of the COVID-19 pandemic has highlighted the importance of Target 3.D of the SDGs, which is to strengthen the capacity of all countries, in particular developing

[20] https://news.un.org/en/story/2021/10/1103022.

[21] https://unstats.un.org/sdgs/report/2021/goal-03.

[22] https://unric.org/en/sdg-3/

[23] Quote available from: https://www.un.org/en/desa/sustainable-development-goals-report-2020.

countries, for early warning, risk reduction and management of national and global health risks.

Whereas life expectancy has tended to rise over time, with an average increase in lifespan of three years for every decade of the twentieth century in Britain, research has shown that life expectancy at birth dropped between 2019 and 2020 in 27 out of 29 countries studied (Aburto et al. 2021). The mortality increases triggered by the COVID-19 pandemic are of a magnitude not witnessed since World War II in Western Europe or the breakup of the Soviet Union in Eastern Europe. These shifts are largely attributable to increased mortality of people aged 60 and over, from official COVID-19 deaths. Males in the USA and Lithuania experienced the largest losses in life expectancy at birth during 2020 (2.2 and 1.7 years, respectively), More than one year was wiped off expected lifespans in 11 countries for males and 8 countries for females. The most significant drops in male life expectancy were recorded for the USA (a drop of 2.2 years) and Lithuania (1.7 years).

Aburto et al.'s (2021) study of changes in life expectancy concludes with the observation that, 'although COVID-19 might be seen as a transient shock to life expectancy, the evidence of potential long-term morbidity due to long COVID and impacts of delayed care for other illnesses (cancer, cardiovascular disease) as well as health effects and widening inequalities stemming from the social and economic disruption of the pandemic suggest that the scars of the COVID-19 pandemic on population health may be longer-lasting.'

Certainly, the pandemic has halted the significant progress which had been made in increasing life expectancy and in reducing child and maternal mortality. In some ways, it has also helped to focus our thinking on the way forward to achieve the SDGs. Ground-breaking research considering the impact of COVID-19 on the Sustainable Development Goals was published in April 2021 (Hughes et al. 2021). Using modelling to consider three potential recovery scenarios, this research shows the ongoing likely impacts of the pandemic over the next decade. As might be expected, the gap between rich and poor countries is likely to widen due to the social and economic impacts of the pandemic. Even prior to the COVID-19 pandemic, the data suggests that the world would have been unlikely to reach the SDG target values for maternal mortality, child mortality or neonatal mortality rates by 2030. On a global average basis, these three targets did appear reachable by 2050, and this appears to be the case in spite of the impacts of COVID-19. However, their modelling also suggests that an 'SDG Push', involving a combination of policies and investment in governance, social protection, the green economy and digitalisation, could enable the least developed countries to exceed their pre-COVID-19 development trajectories. By accelerating progress to the targets, the SDG Push scenario could enable the world on average to achieve each of the health goals by 2030, although at the country level, some of the lowest income countries would still struggle to attain these targets.

From a geographical perspective, during the pandemic, we have witnessed major issues regarding disruption in supply chains, especially in relation to medical products, PPE and other essential goods. The challenges caused by the distance between locations of production and consumption have highlighted the globalised economic system and illustrated that the current neoliberal system of production and supply is out of sync with health and social needs on the ground. Furthermore, such a system is not sustainable either environmentally (due to the CO_2 emissions occasioned by long-distance transport routes), economically (due to the disruptions in these supply chains) or socially (with rising tensions). For more discussion of the impacts of the coronavirus pandemic, see https://www.eiu.com/n/novel-coronavirus-outbreak/.

Future research will tell very different narratives regarding the effects of the pandemic, for instance within India, a major pharmaceutics producer and between India and other countries. Similarly, appraisal of the pandemic experiences within and between European countries and Israel will doubtlessly be significant.

Demographic Futures in Europe and Beyond

As already noted, SDG3 sets out to ensure healthy lives and promote well-being for all at all ages. This last element, 'at all ages', is becoming increasingly relevant in a European context. Across the continent, the population structure is changing and two forms of demographic ageing are being experienced. 'Bottom up' ageing is being seen as birth rates decline and the younger age cohorts of the population pyramid become smaller than the older generations. Meanwhile, 'top down' ageing is also evident as life expectancy increases and the height of the population pyramid grows, representing increasing numbers living into old age. While increased life expectancy should be a cause for celebration, it can also cause policy issues for governments. The ratio of workers to pensioners in Europe is decreasing. Whereas in 1990, there were 5.8 workers for every one pensioner, and this ratio had fallen to 3.9:1 by 2000 and is predicted to fall further, putting a strain on social services and pensions provision.

This long-term shift in disease and cause of death patterns in Europe was explained by Omran (1971) in the epidemiological transition model. Paralleling the demographic transition model, this suggests that there is a shift over time from high mortality (largely from infectious diseases, with most deaths at young ages) to low mortality (with most deaths at older ages, largely due to degenerative diseases). Europe is now experiencing an increase in chronic disease associated with ageing, with heart disease (cardiovascular disease), cancer and diabetes among the major causes of death. Longer life is also associated with a relatively long period of morbidity, so a focus on promoting healthy ageing is needed, including tackling social and cultural behaviour around patterns of food and alcohol consumption. An increased demand for healthcare is inevitable for ageing populations, and this must be recognised in future planning. A 2006 report on healthcare in Europe noted that demographic ageing would increase demands for health services while simultaneously shrinking the pool of workers available to offer these services.[24] Already,

[24] European Observatory on Health Systems and Policies (2006) The Health Care workforce in Europe: learning from experience. Available at https://www.euro.who.int/__data/assets/pdf_file/0008/91475/E89156.pdf.

European countries have been recruiting healthcare staff, including workers in long-term care homes for the elderly, from non-EU countries. This trend is likely to persist, despite the negative impact that this brain-drain will have on the countries of origin.

As the previous sections have demonstrated, the countries of Europe have a mixed score card in relation to SDG3, but are performing better overall than many regions which have fewer socio-economic advantages. While there are clearly aspects which individual European countries need to address internally, in relation to alcohol consumption and non-communicable diseases for example, it is important to the overall achievement of the SDGs that European countries and institutions look outwards. Global inequalities have been brought into sharp focus due to the COVID-19 pandemic, and it is clear that the negative impacts will be keenly felt into the future. In order for the 'SDG Push' to be successful, wealthy countries and regions must provide support. This includes direct financial support through overseas development aid (ODA) budgets. The United Nations target is for governments to contribute at least 0.7% of GNI to ODA. Preliminary OECD data for 2020 shows that only six countries (of 29 listed) had reached or exceeded that target, namely Luxembourg, Norway, Sweden, Denmark, Germany and the United Kingdom.[25] The institutions of the European Union are also significant donors of ODA, indeed the EU is one of the top three donors of development aid in the world, although it has yet to reach the target of donating at least 0.7% of its gross national income annually. In the light of the pandemic and the effects of climate change, the European Commission increased its 2021 annual humanitarian budget by over 60% compared with that adopted in 2020.[26] However, as is stated in official EU documentation, financial aid alone is not sufficient to achieve the sustainable development goals. Political action is also required.[27]

One example of where political action could assist in relation to SDG3 relates to vaccine equity. During the pandemic, the international legal agreement in relation to intellectual property—known as Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)—came into sharp focus. This agreement which is administered by the World Trade Organisation concerns the regulation by national governments of different forms of intellectual property (IP) as applied to nationals of other WTO member countries. Controversy previously arose over AIDS drugs in Africa, where it was shown that patents had resulted in high drug costs for public health programmes. This resulted in the Doha Declaration, issued in November 2001, which indicated that TRIPS should not prevent states from dealing with public health crises. However, in spite of this interpretative statement, in 2020 new conflicts emerged in relation to patents and copyrights related to the vaccines, diagnostics and treatments associated with COVID-19. As of 17 June 2021, around 68 vaccines were administered for every 100 people in Europe and Northern America compared with fewer

[25] https://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/official-development-assistance.htm.

[26] https://ec.europa.eu/echo/news/eu-boosts-humanitarian-aid-budget-2021-needs-rise_en.

[27] https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/international-economic-relations/international-development-aid_en.

than 2 in sub-Saharan Africa.[28] In October 2020, it was proposed that the WTO would grant a temporary waiver (the TRIPS waiver) to enable more widespread production of the vaccines, which would be beneficial to the global population. Although this was supported by over 100 developing nations, the proposal was blocked by the G7 members (which include France, Germany, Italy and the UK). Learn more about the call for affordable access to COVID-19 vaccines for everyone in this video from DW News: https://youtu.be/CTEGQMJVLZ8.

The European Parliament failed to reach consensus in relation to a revised TRIPS waiver proposal in May 2021, although the Parliament's resolution of 20 May 2021 on accelerating progress and tackling inequalities towards ending AIDS as a public health threat by 2030 also called on the EU to support the TRIPS waiver.[29] Indeed, this resolution called for the EU to set up a clear and coherent EU global COVID-19 vaccination strategy, focusing on ensuring equal, affordable and timely access to vaccination for people in developing countries. It also called on the Commission and Member States 'to ensure that the global response to COVID-19 includes lessons learned from the fight against HIV, such as: protecting human rights and addressing stigma and discrimination, particularly among key and other vulnerable populations; fighting gender barriers to health; supporting healthcare practitioners and researchers, especially in low-resource settings; engaging communities in the response; and fairly allocating limited resources and new tools so that no one is left behind'. The resolution urged the EU to establish a comprehensive global strategy and road map for the achievement of the SDGs, called for an effective long-term EU global health strategy and insisted 'that the Commission needs to redouble its efforts and intensify its work towards effective global health programmes targeting healthcare systems in developing countries'.

The need for political action in order to achieve the SDGs, including SDG3, is evident from the work of the United Nations and is also clearly recognised within Europe, as the resolution of 20 May 2021 demonstrates. The interconnected nature of our world has come into sharp focus with the COVID-19 pandemic. It has also become clear that actions to improve public health and preparedness will be beneficial for all. Therefore, if European countries fail to act from a moral and ethical standpoint, perhaps they can be prevailed upon to do so for pragmatic reasons. 'We are at a critical juncture in human history', according to the Under-Secretary-General of the UN Department of Economic and Social Affairs, Liu Zhenmin. If we learn from the pandemic, we can rise to the challenges which face us now and into the future. As the most recent Sustainable Development Goals Report (2021) highlights, addressing COVID-19 has demonstrated community resilience, decisive government action, rapid expansion of social protection and unique collaboration to develop life-saving treatments in record time. All of these positive impacts could form the basis for unprecedented action to achieve the Sustainable Development Goals not just in Europe, but globally.

[28] https://www.un.org/en/desa/sustainable-development-goals-sdgs, page 32 of the report, accessed 14 October 2021.

[29] https://www.europarl.europa.eu/doceo/document/TA-9-2021-0250_EN.html.

Acknowledgements The author would like to acknowledge the constructive comments and suggestions from Dr. Gerry O'Reilly and an anonymous reviewer on a previous draft of this chapter.

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SDG 4. Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities for All

New Horizons for Quality Education Within the Framework of the 2030 Agenda

Belén Sáenz-Rico de Santiago and M. Rosario Mendoza Carretero

Abstract A world that is interconnected and finite, combined with knowledge management for the benefit of the few (Boff in Ética planetaria desde el gran sur. Trotta, 2001), mean that educational institutions must strive, with commitment and determination, to ensure the education and training of future citizens.The economic, social, and environmental dimensions of the concept of sustainable development make it possible to achieve development that is both sustainable and dynamic, through the use of a general framework of action whose slogan "Leave no one behind" is directly linked to the key goal of ensuring inclusive and equitable quality education, as set out in the 2030 Agenda (UN in Resolution adopted by General Assembly on 25 September 2015, 2015). The global challenges facing the planet demand professionals and citizens who possess skills for sustainability and act as agents to ensure that the immediate needs of our local societies-both current and future-are met (Novo in El desarrollo sostenible. Su dimensión ambiental y educativa, UNESCO. Pearson Educación, 2006; Murga-Menoyo in Foro de Educación 13(19):55–83, 2015). Education needs to connect different areas of knowledge in order to meet the challenge of preparing the professionals of the future, in light of the fact that-despite the considerable progress made in terms of access to and participation in education-in 2017 there were still 262 million children and adolescents who did not attend school. This figure represents almost one-fifth of the global population of school-age children, and highlights the role that territory can play in human development.We present a descriptive analysis of performance in relation to SDG 4, using the UN's annual reports from 2015 to 2020 within the European context to identify the changes that have taken place in education in general, and in the processes of teaching and learning in particular, with regard to quality education.

Keywords Quality education · Inequity · Territory · Skills for sustainability

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_4

The approval of the 2030 Agenda for Sustainable Development by the General Assembly of the United Nations (UN 2015), with its 17 goals and 169 targets, represents a paradigm change in how we approach the development of our planet. Evidently, this has important repercussions for the world of education. We are constantly transitioning between social, economic, and environmental spaces that shape our own development, both individual and global; at the same time, these spaces reflect the equality or inequality, or the equity and inequity, of our planet. These three development contexts should be viewed as nodes in an interdependent sociological network that marks out the strengths and weaknesses of both the planet and human development.

Although Europe is leading the world in the achievement of the SDGs, the rate of progress is not the same for every European country (SDSN and IEEP 2019). Consequently, despite being the most egalitarian continent, Europe also presents major disparities and faces urgent challenges (Kloke-Lesch 2018) in its aim to "leave no one behind". To achieve this aim, the European Union (EU) must strengthen the social inclusion of all of the people living in the diversity of territories that make up the region, and reduce the inequalities (access to public services and infrastructure, gender, income, etc.) in human development (SDSN and IEEP 2019). This links directly to the key goal of ensuring inclusive and equitable quality education, in line with the conviction that education can provide the foundation for transforming societies, people and nations.

Thus, education plays a key role in achieving equality between individuals. Through education, it is possible to reduce inequality in terms of access to education and to ensure that everyone, regardless of their personal circumstances, is able to complete various stages of education (European Union 2017), including those who live in rural areas (SDSN and IEEP 2019). Through education, we can improve "employability, productivity, innovation, and competitiveness" (European Union 2018, 83) and thereby transform both the medium and our own personal narrative (León 2007).

SDG 4, Quality Education (UN 2015), seeks to increase the number of young people and adults who possess relevant skills for the achievement of employment, decent work, and an entrepreneurial spirit, and to eliminate gender disparities and achieve access to education at the global level. Moreover, it seeks to empower every individual so that they have the ability to lead independent, healthy, and sustainable lives; to which end, it is necessary to achieve universal numeracy and literacy and to acquire knowledge and skills that enable the promotion of sustainable development.

This change requires a capacity-oriented, innovation-based education model that makes it possible to accelerate the convergence in living standards (SDSN and IEEP 2019); it is therefore necessary to transform the education system in order to benefit all citizens and reduce the potential of digital technologies—aggravated by the context of COVID-19—to amplify social divides (COTEC 2020); SDSN and IEEP 2019). In this respect, there is evidence of a greater negative impact on access to education in populations that are not sufficiently equipped with digital technologies and training for this transformation toward the digitalization of the teaching and learning process (SDSN and IEEP 2020, 18).

Consequently, "EU countries must increase investments in innovation, educational quality and the development of skills for lifelong learning, including digital skills for all" (SDSN and IEEP 2020, viii) in order to accelerate "the convergence in living standards" (SDSN and IEEP 2019, 9, 2020, vii). The formation of human capital through education and training advances academic knowledge and innovative technologies, which in turn contribute to job creation, labor productivity, and resource efficiency (European Union 2015).

To explore this issue further, we present a descriptive analysis of performance in relation to SDG 4, using the UN's annual reports on Europe from 2015 to 2020 to identify the changes that have taken place in current teaching and learning processes in order to achieve quality education oriented toward sustainable development.

Quality Education in Europe: A Reality, or a Distant Goal?

"An inclusive and quality education for all is an essential element of sustainable development" (European Union 2016, 42). The field of education reflects the existence of interlinked relationships in human development as a whole, in light of the fact that through education, citizens are able to "gain and update the knowledge, skills and competences needed for employment, social inclusion, and personal fulfillment" (European Union 2015, 115).

Today, however, there is still clear evidence of educational inequality (in terms of access to education, leaving school early, higher levels of education, etc.) in some EU Member States. "With their transience and inertia, territorial factors condense persistent processes of inequality; at the same time, however, they are the ideal vehicle for understanding how these inequalities are produced and reproduced" (Di Virgilio and Serrati 2019, 18). Consequently, territorial and educational inequalities appear to interact with one another (Di Virgilio and Serrati 2019).

In line with this assertion, it would be useful to identify any interlinked relationships that may exist between the codes of inequality, territory, and education and which converge within the context of SDG 4. Quality Education. To do this, we used the ATLAS.ti program (version 9) to perform a content analysis (Bardin 2002) of the targets that comprise the goal, which was established by the United Nations in the resolution approved by the General Assembly on September 25, 2015.

The results show that there are synergies between the codes of inequality, territory, and education in target 4.5, which seeks to eliminate gender disparities in education and ensure equal access to all levels of education and training (UN 2015); target 4.b, which seeks to expand the number of scholarships (UN 2015); and target 4.c, which seeks to increase the supply of qualified teachers, "especially [in the] least-developed countries and small island developing States" (UN 2015, 20) (Fig. 1).

As well as the demonstrated links between the codes mentioned above, it would also be helpful to consider the relationships between the codes of inequality and education, given that educational inequality seems to play a fundamental role in "exacerbating the rest of the inequalities, inasmuch as it allows for the consolidation

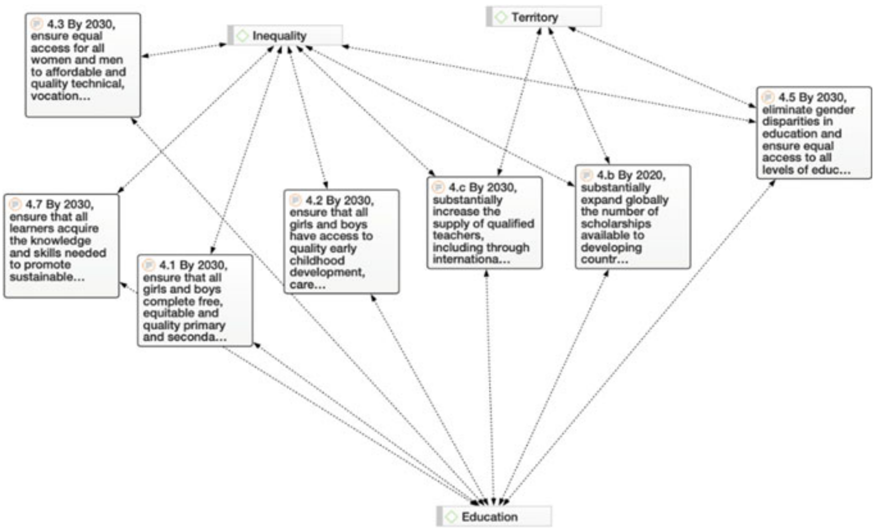

Fig. 1 Connected relationships between the inequality, territory and education codes. *Source* Self-made

and legitimization of inequalities related to background" (Di Virgilio and Serrati 2019, 13). We should therefore underline the need for all children to complete primary and secondary education (target 4.1) and ensure that they have access to quality early childhood development and care and pre-primary education, so that they are ready for primary education (target 4.2); likewise, it is necessary to ensure access to higher education (technical, vocational, and/or university education) regardless of gender (target 4.3) and the acquisition of theoretical and practical knowledge that promotes sustainable development (target 4.7) (Fig. 2).

Although the EU[1] has made significant process in increasing participation in education in recent years, there are still hurdles to overcome in order to ensure inclusive and equitable quality education for all of European society. This prompted us to pose a number of questions, such as: do all children receive early childhood education? Do all school-age children complete their basic education? Can their place of residence negatively affect students' academic performance? How many people continue their academic and/or professional education and training? These are some of the questions we will attempt to answer in this chapter.

[1] The United Kingdom is included as a Member State as it was part of the European Union until February 1, 2020.

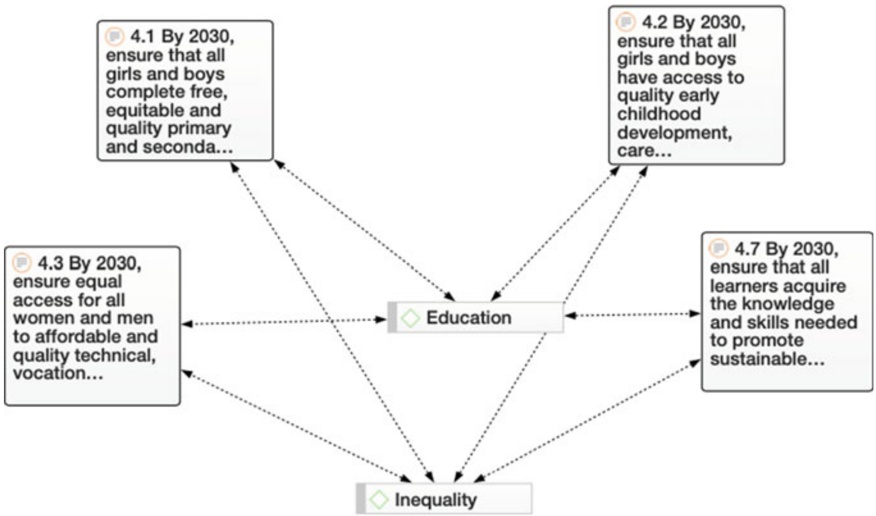

Fig. 2 Connected relationships between the inequality and education codes. *Source* Self-made

Educational Inequalities in Basic Education

Basic education, which includes early childhood, primary and secondary education, needs to be equitable and of sufficient quality, so that every pupil is able to optimize their personal development and make progress within society.

With regard to children's participation in early childhood education, the evidence shows that the majority of European countries have achieved this goal, although countries such as Bulgaria, Croatia, Greece, and Switzerland face a number of challenges in the form of certain education-related structural deficits that persist and are preventing them from achieving this goal. However, we should note the progress made by Slovakia, where the corresponding figure rose from 78.2% in 2017 to 82.2% in 2018, and the decline experienced in Greece, where the figure fell from 81.5% in 2017 to 75.2% in 2018 (Table 1).

Additionally, it should also be noted that in 2017, in the EU as a whole, 95.7% of children aged between four and the starting age of compulsory primary education attended school (SDSN and IEEP 2019), although in the most recent data available (which are for 2018) this figure had fallen to 94.8%. Nonetheless, this represents an increase of 0.9% since 2013 (European Union 2020; SDSN and IEEP 2020).

With regard to primary education, we can affirm that this stage of education helps all pupils to gain competences in numeracy and literacy, along with other foundational skills, by the time they have completed their primary education (European Union 2016). In the EU, the number of pupils enrolled in primary education has gradually increased: in 2015, there were some 28,761,576 children enrolled, while in 2019 this figure had grown to a total of 29,381,503. Lower rates of enrolment were observed in Estonia (89,618) and Lithuania (117,676), as shown in the following image (Fig. 3).

Table 1 Participation in early childhood education

Country	2017 (%)	2018 (%)	Country	2017 (%)	2018 (%)
France	100.0	100.0	Ireland	100.0	100.0
United Kingdom	100.0	100.0	Belgium	98.7	98.5
Denmark	98.0	100.0	Netherlands	97.6	96.9
Spain	97.4	98.0	Luxembourg	96.6	96.1
Malta	96.5	95.3	Germany	96.4	96.0
Latvia	96.0	96.3	Sweden	96.3	95.9
Austria	95.6	96.0	Hungary	95.6	95.7
Italy	95.1	94.9	Portugal	94.2	93.7
Estonia	92.9	92.8	Slovenia	92.1	93.1
Cyprus	92.0		Czech Republic	92.0	91.5
Lithuania	91.9	91.0	Poland	91.9	93.0
Romania	89.6	86.3	Finland	87.8	89.3
Bulgaria	83.9	82.4	Croatia	82.8	81.0
Greece	81.5	75.2	Slovak Republic	78.2	82.2
Switzerland		73.6			

Source Self-made (adapted from SDSN and IEEP 2019, 2020)

In recent years, lower levels of performance have been observed in the areas of reading, mathematics, and science. These are skills which provide "key insights into the performance of school systems and pupils' basic skills attainment" (European Union 2016, 42). The ability to read a text and perform mathematical calculations provides the foundation for learning and the gaining of specialized skills, thereby making it possible to reduce social exclusion and ensure that everyone participates actively in society (European Union 2016). However, the figures for 2019 show that at the global level, children only achieved moderate levels of proficiency (UN 2019a).

In this respect, it would also be relevant to consider the results of the latest Program for International Student Assessment (PISA), which collates the average scores of European students after they have completed their compulsory education. The scores correspond to the areas of reading (range of the average score achieved by the students: 523–0), mathematics (range of the average score achieved by the students: 523–430) and science (range of the average score achieved by the students: 530–424) (OECD n.d.) (Figs. 4, 5 and 6).

Moreover, family influence plays an extremely important role in children's academic performance, as well as in social inclusion. This is corroborated by the data from 2015, which show that 65.6% of children aged 0–17 came from families in which the parents had only received a primary and lower secondary education. These children were at an increased risk of poverty or social exclusion; moreover, the risk was higher (68.2%) for younger children (age range 0–6). Consequently, there is also a correlation between the parents' level of educational attainment and their children's academic performance, as a lower level of educational attainment equates

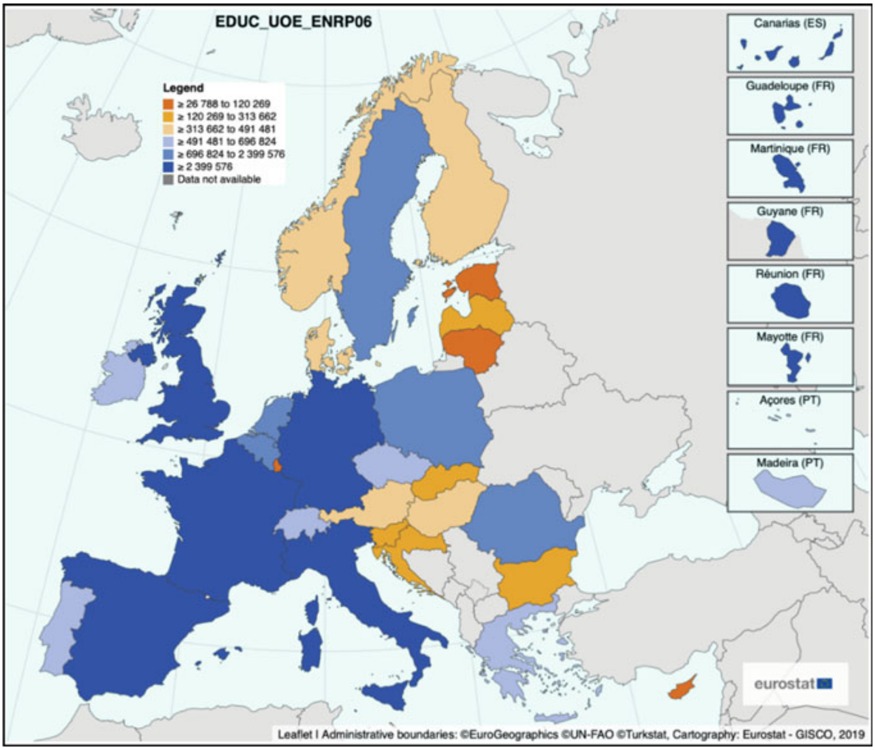

Fig. 3 Pupils enrolled in primary education by sex and NUTS2 regions, 2019. *Source* Eurostat (2021a, b, c).

to a greater likelihood of social exclusion and leaving school early (European Union 2017). This leads to the second question we posed above: Do all school-age children complete their basic education?

Undoubtedly, despite the reasonable progress made with regard to completion of primary education, there are still many students who do not complete this stage. It is therefore necessary to accelerate this process in order to reduce the number of early school leavers (UN 2020): leaving school early has a negative impact on young adults, as they run the risk of being unemployed or working in low-paid jobs (European Union 2015, 2018). As a result, leaving compulsory education and training early has an impact on access to the labor market, and therefore on social exclusion and personal well-being.

This indicator suggests that in order for education to be of sufficient quality, students not only require access to primary and secondary education (both upper and lower), but must also complete these stages in their entirety (European Union 2018). In fact, the evidence shows that in 2017, approximately 55.7% of young people with a lower secondary education were either unemployed or inactive; furthermore, we should also note that between 2008 and 2017, the number of early school leavers

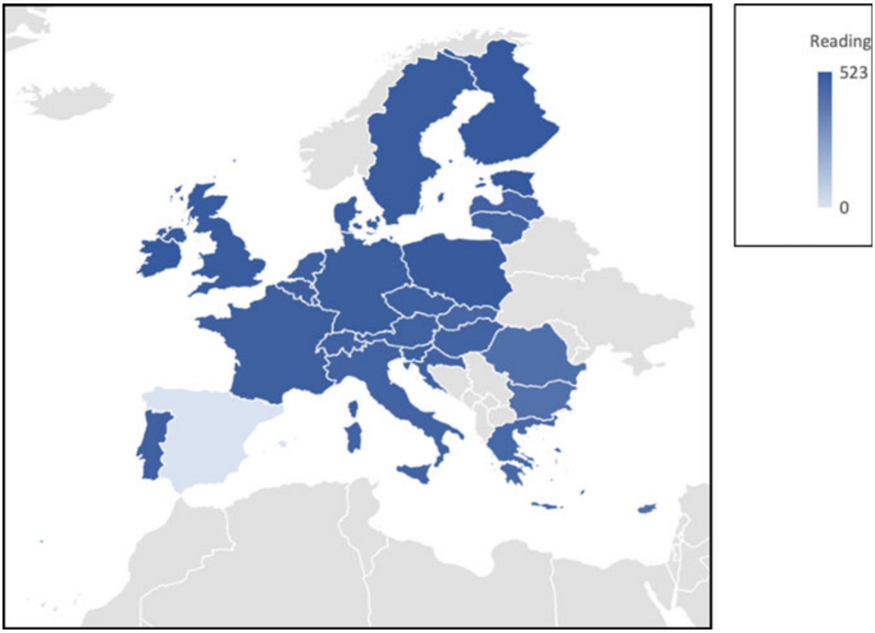

Fig. 4 Students' performance in reading. *Source* Self-made (adapted OECD 2018)

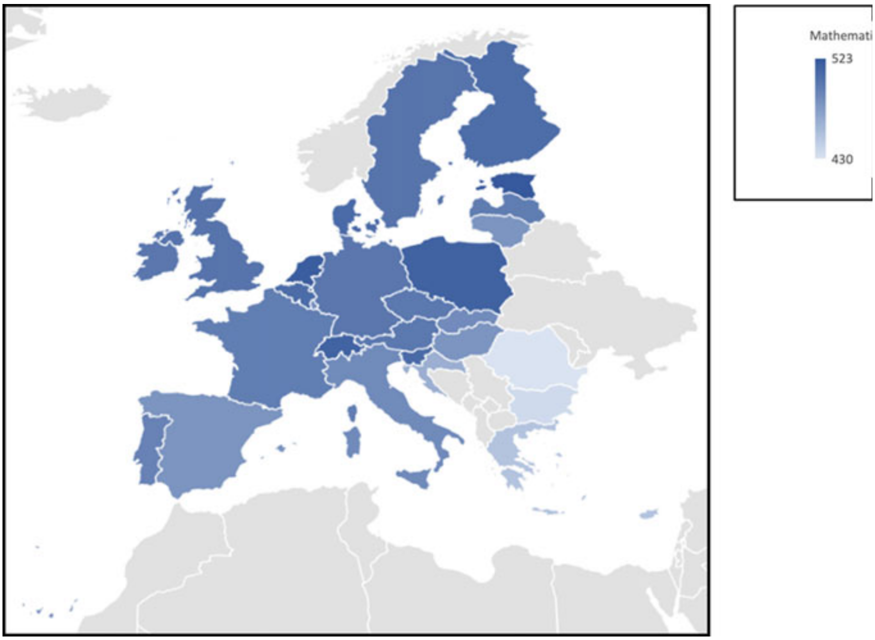

Fig. 5 Students' performance in Mathematics. *Source* Self-made (adapted OECD 2018)

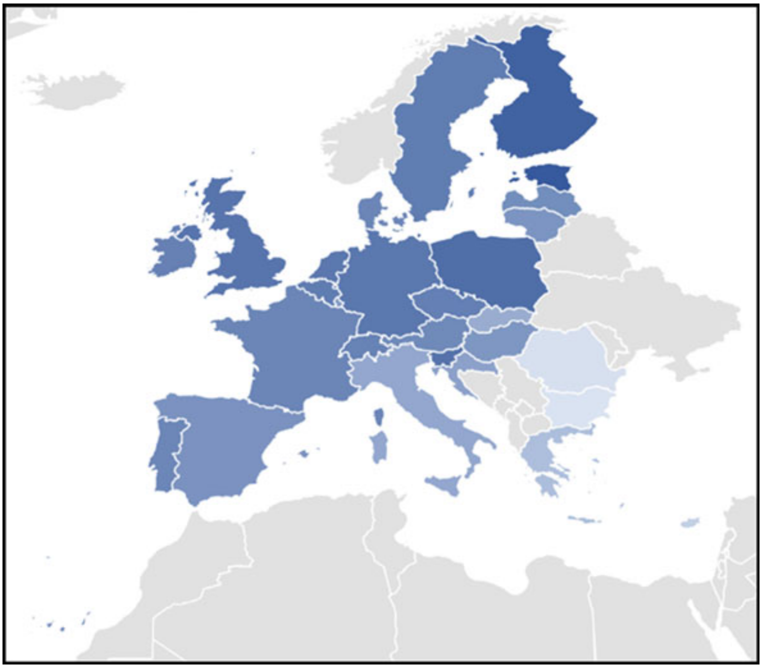

Fig. 6 Students' performance in Science. *Source* Self-made (adapted OECD 2018)

who were looking for work increased from 30.6% to 34.9% (European Union 2018; Eurostat 2021b).

In 2014, the difference in the proportion of early leavers ranged from 2.7% in Croatia to 21.9% in Spain. The lowest figures were recorded in Croatia, Slovenia, Poland, the Czech Republic and Lithuania, whose rates were below 6%, while the highest figures were recorded in Spain, Malta, Romania, and Portugal, where the rates were 17% or higher. Between 2009 and 2014 the figures fell dramatically in the countries of southern Europe, particularly in Portugal (from 30.9% to 17.4%), Spain (from 30.9% to 21.9%), Malta (from 25.7% to 20.4%), and Cyprus (from 11.7% to 6.8%). Latvia also recorded a significant drop (from 14.3% to 8.5%). By 2017, this indicator had fallen yet further, to 10.6% (European Union 2018), owing to the fact that in 2015 a target was set to reduce the rate of early leavers to less than 10% by 2020 (European Union 2015, 36).

Despite this, in 2017 64 million children aged 6–11 did not attend primary school, 61 million younger adolescents (ages 12–14) did not attend lower secondary education and 138 older adolescents (ages 15–17) did not attend upper secondary education (UN 2019b). In 2019, 10.2% of young people aged 18–24 had only completed, at best, their lower secondary education (Eurostat 2020).

The figures for 2019 reveal that some EU countries had already achieved the target set for 2020, while others continue to work towards ensuring that young people aged

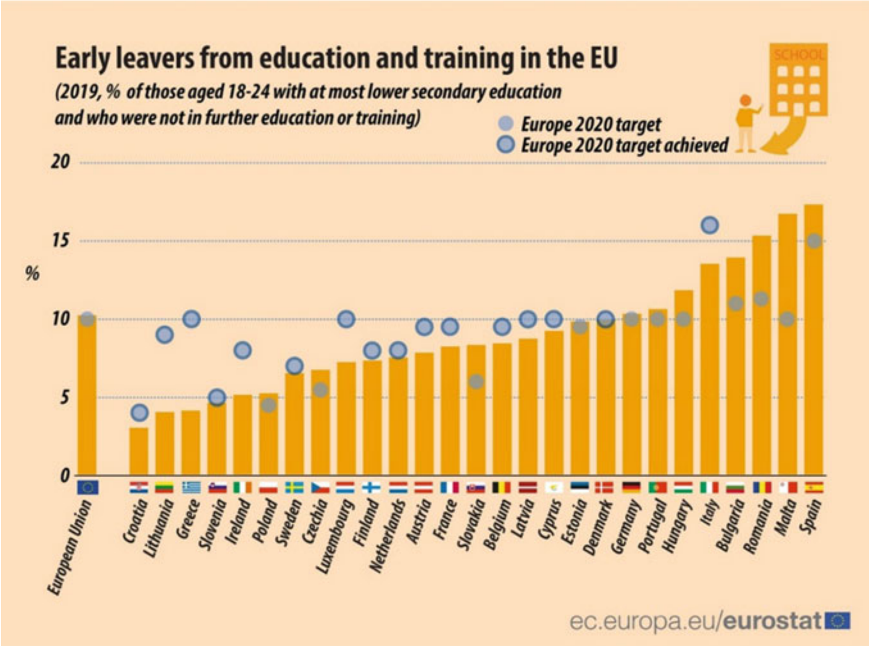

Fig. 7 Early leavers from education and training in the EU. *Source* Eurostat (2020)

18–24 do not leave education and training early, in light of the fact that people with a lower level of educational attainment due to leaving early are more likely to have fewer job opportunities (European Union 2015, 2018) and are "more likely to live in poverty and social exclusion" (European Union 2018, 87) (Fig. 7).

Taking these results into account, it should be noted that at least 85% of 22 year olds should have completed their upper secondary education (European Union 2015, 135). This is the minimum desired level for European citizens, as the skills and competences students will gain at upper secondary level are considered essential for successful entry into the labor market and as the foundation of lifelong learning (European Union 2018).

However, it should be pointed out that the number of early school leavers fell during the economic crisis of 2008, as students elected to continue their education in response to the lack of jobs. Current data show that the EU is on track to reducing the number of 18 to 24 year olds who leave education and training early. The rate sits at 10.6% (SDSN and IEEP 2019), having fallen to 10.2% in 2019 (European Union 2020; SDSN and IEEP 2020). The analysis of the EU countries reveals that the majority of them have reduced the early leaving rate: examples include Lithuania (4.6% in 2018; 4.0% in 2019), Sweden (9.3% in 2018; 6.5% in 2019) and Greece (4.7% in 2018; 4.1% in 2019). The country with the lowest proportion of early school leavers is Croatia. Other countries, such as Malta and Iceland, face significant challenges in reducing this particular indicator (Table 2).

Table 2 Early school dropout

Country	2018 (%)	2019 (%)	Country	2018 (%)	2019 (%)
Croatia	3.3	3.0	Austria	7.3	7.8
Slovenia	4.2	4.6	Netherlands	7.3	7.5
Lithuania	4.6	4.0	Cyprus	7.8	9.2
Greece	4.7	4.1	Finland	8.3	7.3
Poland	4.8	5.2	Latvia	8.3	8.7
Ireland	5.0	5.1	Belgium	8.6	8.4
Czech Republic	6.2	6.7	Slovak Republic	8.6	8.3
Luxembourg	6.3	7.2	France	8.9	8.2
Sweden	9.3	6.5	Denmark	10.2	9.9
Estonia	11.3	9.8	United Kingdom	**10.7**	**10.9**
Germany	10.3	10.3	Portugal	11.8	10.6
Hungary	12.5	11.8	Bulgaria	**12.7**	**13.9**
Italy	14.5	13.5	Romania	16.4	15.3
Spain	17.9	17.3	Iceland		17.9
Malta	17.5	16.7			

Source Self-made (adapted from SDSN and IEEP 2019, 2020)
Note Significance of bold: Countries and percentages obtained in both 2018 and 2019 in early school dropout

Other vulnerable groups that are also confronted with this situation include migrants and people with disabilities. Some 22% of people with disabilities left education and training early, in comparison to their counterparts without disabilities (11.7%), although it should also be noted that 29.4% of people with disabilities completed the tertiary stage of education (European Union 2018). Similarly, people from a migrant background tend to face greater difficulties in continuing and completing their education. This is particularly true for males, of whom 21% leave education and training early (Eurostat 2021b). The figures for 2017 reveal significant differences (more than 4 percentage points) between the number of native residents attending tertiary education and the equivalent figure for those from a migrant background (European Union 2018).

It should also be noted that the gender gap for this indicator has fallen between men and women in the 18–24 age group. Progress in this respect was stronger for men: in 2017 the gender gap narrowed to 3.2%, bringing the men's figures closer to those for women (European Union 2018). However, the same report shows that those in this category are more likely to leave education and training early. The figures for 2017 show that 12.1% of men left education early compared to 8.9% of women, thus demonstrating that the latter group tends to participate more actively in education.

Drawing on all of these data, we can affirm that people with a lower level of education are recognized as vulnerable groups; therefore, it is necessary to promote the participation of these young people in higher education and lifelong learning

(European Union 2018), as this will improve their performance in the labor market (European Union 2015). However, the question remains: how many people continue their academic and/or professional education and training?

Higher Education in Europe: Tertiary Education and Lifelong Learning

Tertiary education, understood as university or university-equivalent education, has gradually become more common, increasing from 23.6% in 2002 to 37.9% in 2014. This may be due to the direct correlation between level of education and employment rate, as a higher level of education may lead to increased employability (European Union 2015). In fact, in 2014 82.1% of people with tertiary education were employed; a figure that is higher than the average employment rate in the EU for the same year (69.2%). In contrast, only 51.9% of those with (at most) a primary or secondary education were employed (European Union 2015).

Between 2002 and 2014, the tertiary educational attainment rates of 30 to 34 year olds increased. In Europe, this figure exceeded 40% in some 16 countries, especially those in northern and central Europe; however, the equivalent figure was less than 30% in the Czech Republic, Slovakia, Malta, Romania and Italy (European Union 2015). In 2018, 40.6% of 30 to 34 year olds in the EU had successfully completed their tertiary education (SDSN and IEEP 2019). Although this figure fell to 40.3% in 2019 (European Union 2020; SDSN and IEEP 2020), it represents an increase of 3.8% over the equivalent figure for 2014. In 2019, 80.9% of 20 to 34 year olds with a tertiary education were employed (European Union 2020) (Fig. 8).

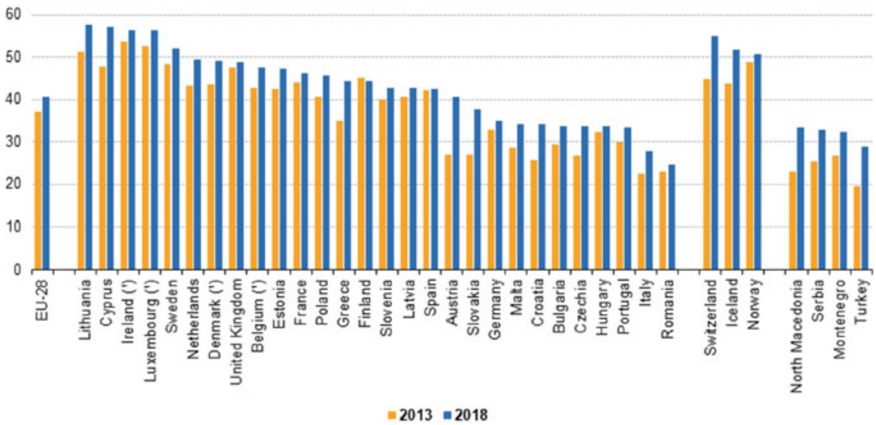

Fig. 8 Tertiary educational attainment by country, 2013 and 2018 (% of population aged 30 to 34). *Source* Eurostat (2019)

In 2019, some 19 EU Member States (three more than in previous years), including the United Kingdom, reached the target attainment rates for tertiary education. Notable progress was made in Spain, which grew from 42.4% in 2018 to 44.7% in 2019; Austria, which grew from 40.7% in 2018 to 44.7% in 2019; Latvia, which grew from 42.7% in 2018 to 45.7% in 2019; and Slovenia, which grew from 37.7% in 2018 to 40.1% in 2019.

However, despite the progress made by the EU Member States, some countries must continue to work towards achieving the target that has been set. One example is Malta, which has almost reached the target given that the country's corresponding figure for 2019 was 37.8% (Table 3).

Despite the increase in the number of people aged 30–34 who completed their tertiary education between 2002 and 2017, we can affirm that with regard to gender, the figures reveal a greater increase for women (from 24.5 to 44.9%), with a much slower increase for men (rising from 22.6% in 2002 to 34.9% in 2017) (European Union 2018). Four years later, this trend appears to have continued, as men still lag behind women with regard to completion of tertiary education, even though many women are "economically inactive due to caring responsibilities" (European Union 2018, 12) and their employment rate is lower.

In addition to tertiary education, it is also important to examine data that provide information on lifelong learning, a process that enables all citizens to improve their skills and knowledge regardless of their age. Lifelong learning can involve formal, non-formal, and informal processes. Adults aged 25–64 who left the initial process

Table 3 Tertiary educational attainment

Country	2018 (%)	2019 (%)	Country	2018 (%)	2019 (%)
Lithuania	57.8	57.6	Sweden	52.0	52.5
Cyprus	57.1	58.8	Netherlands	49.4	51.4
Ireland	56.3	55.4	Denmark	49.1	49.0
Luxembourg	56.2	56.2	United Kingdom	48.8	50.0
Belgium	47.6	47.5	Estonia	47.2	46.2
France	46.2	47.5	Poland	45.7	46.6
Greece	44.3	43.1	Finland	44.2	47.3
Latvia	42.7	45.7	Slovenia	42.7	44.9
Spain	42.4	44.7	Austria	40.7	44.7
Slovak Republic	**37.7**	**40.1**	Germany	34.9	35.5
Malta	34.2	37.8	Croatia	34.1	33.1
Bulgaria	33.7	32.5	Czech Republic	33.7	35.1
Hungary	33.7	33.4	Portugal	33.5	36.2
Italy	27.8	27.6	Romania	24.6	25.8

Source Self-made (adapted from SDSN and IEEP 2019, 2020)
Note Significance of bold: Countries and percentages obtained in both 2018 and 2019 in tertiary educational attainment

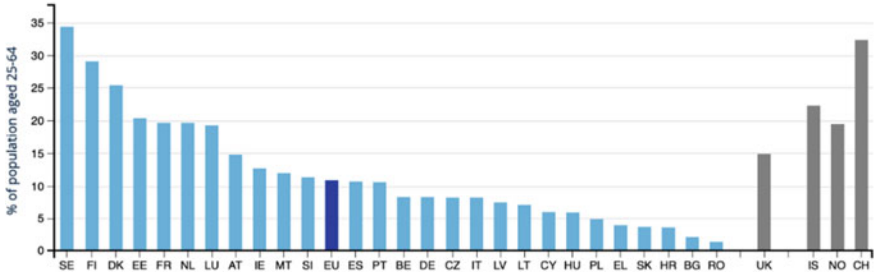

Fig. 9 Adults participating in learning, 2019 (% of population aged 25 to 64). *Note* SE (Sweden); FI (Finland), DK (Denmark); EE (Estonia); FR (France); NL (Netherlands); LU (Luxembourg); AT (Austria); IE (Ireland); MT (Malta); SI (Slovenia); EU (EU27); ES (Spain); PT (Portugal); BE (Belgium); DE (Germany); CZ (Czech Republic); IT (Italy); LV (Latvia); CY (Cyprus); HU (Hungary); PL (Poland); EL (Greece); SK (Slovakia); HR (Croatia); BG (Bulgaria); RO (Romania); UK (United Kingdom); IS (Iceland); NO (Norway); CH (Switzerland). *Source* Eurostat (s.f.)

of formal education and training at some stage in the past are able to participate in a wide range of activities, whether general or professional in scope, that are designed to promote their participation in society, enable the acquisition of new skills and reduce existing inequalities (European Commission 2018).

In 2019, 10.8% of adults continued to undergo training across the 27 EU Member States. In Europe, Sweden (34.3%), Switzerland (32.3%), and Finland (29%) had the highest number of adults continuing their education, while Romania (1.3%), Bulgaria (2%), Croatia (3.5%), Slovakia (3.9%), and Greece (3.9%) had the lowest (Fig. 9).

It should be noted that the trend in Europe is increasing, climbing from 5.3% in 2002 to 10.8% in 2019. The greatest increase, which was more than one percentage point, occurred between 2012 (8.2%) and 2013 (9.9%). However, the results show that in Europe as a whole, the average number of people who decided to continue their education in later life (i.e. between the ages of 25 and 64) is lower than the equivalent figure for Sweden (34.3%), Switzerland (32.3%) and Finland (29%); countries that are located in northern Europe (Sweden and Finland) and central Europe (Switzerland).

Of these three countries, throughout most of the period in question Switzerland has remained at the top of the list, as its citizens appeared to participate more actively in lifelong learning; however, in 2006 the figures for Finland (23.1%) were very close to those for Switzerland (22.5%), with the same occurring in 2009 when the three countries had very similar percentages (Finland 22.1%, Sweden 22.5%, Switzerland 23.9%) of citizens participating in lifelong learning. However, of these three countries, Sweden (34.3%) has recorded the greatest increase in participation rates over time, eventually overtaking Switzerland (32.3%) in 2019 (Figs. 10 and 11).

In contrast, the rates for some EU Member States (e.g. Romania) are lower. The figure below reveals a gradual increase on the part of Greece, i.e. a greater number

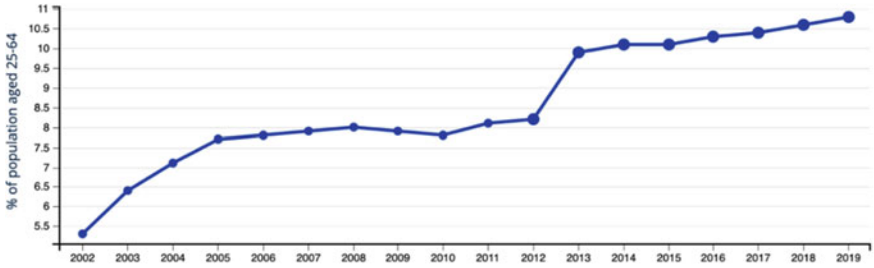

Fig. 10 Adults involved in learning in Europe (2002–2019). *Source* Eurostat (s.f.)

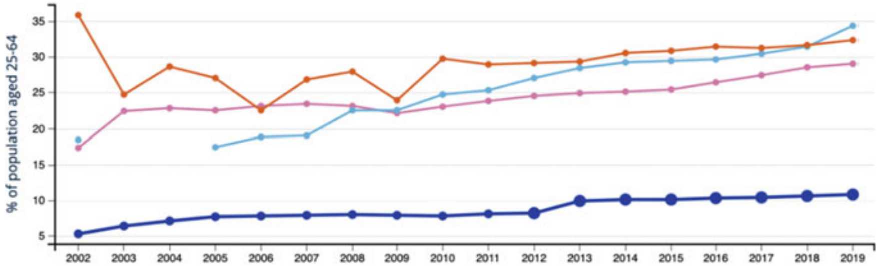

Fig. 11 Comparison between EU27, Finland, Switzerland, and Sweden of adults involved in learning (2002–2019). *Note* Orange (Switzerland); pink (Finland); light blue (Sweden); dark blue (EU27). *Source* Eurostat (s.f.)

of adults participating in lifelong learning; however, the numbers for Croatia remain steady, as do those for Romania and Bulgaria. Of the five Member States shown, it would appear that Slovakia experienced an increase a number of years ago (2002–2008) (Fig. 12).

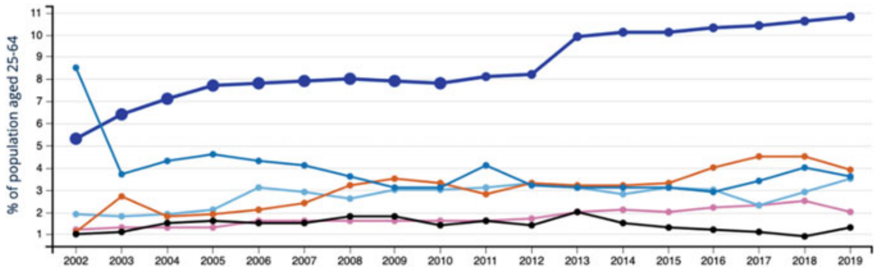

Fig. 12 Comparison between EU27, Slovakia, Croatia, Romania, Bulgaria and Greece of adults involved in learning (2002–2019). *Note* Dark blue (Slovakia); light blue (Croatia); black (Romania); pink (Bulgaria); orange (Greece). *Source* Eurostat (s.f.)

Expenditure on Education and Its Impact on the Development of European Citizens

In the EU, public expenditure on education as a percentage of GDP rose slightly from 4.54% in 1998 to 4.72% in 2017 (World Bank 2020a). However, this averaged figure hides considerable variations between countries, as expenditure on education ranged from 3.1% (Romania) to 6.4% (Finland) in 2017 (World Bank 2020a). The EU-28, for which data is only available from 2002 onwards, followed a similar trend to the EU-27.

In these countries, according to the figures reported by the World Bank (2020b) current education expenditure in the category of primary education did not increase notably between 1998 (93.5%) and 2017 (93.9%), although investment levels rose somewhat more in 2012 (94.6%). A similar pattern was observed for current education expenditure in the category of secondary education (94% in 1998; 94.9% in 2017), with the lowest figure being recorded in Latvia (88.7%) and the highest in Croatia (97.9%) (World Bank 2020c). Expenditure per student at secondary level (% of GDP per capita) reached its highest point in 2002 (28.1%), before falling by a total of five percentage points in the years leading up to 2017 (23%). The EU Member State that spends the least per student is Ireland (15.9%), while the country that spends the most is Cyprus (39.3%) (World Bank 2020d).

In 2016, the EU spent 21.7% on tertiary education. The lowest figure was recorded in 1993, when spending was just 17.9%. After more than 10 years, the increase is evident, although countries such as Luxembourg and the Czech Republic invested a total of just 13% in 2015 and 2016, respectively (World Bank 2020e). Despite these figures, expenditure per student on tertiary education has fallen steeply: in 1998 investment stood at 32%, while by 2016 it had decreased by six percentage points to 26.3%. Of all the Member States, Greece invests the least (11.2%), while Malta invests the most (44.4%) (World Bank 2020f).

The data obtained from the World Bank raise the question of whether place of residence negatively affects students' academic performance, given that—as we have seen—some Member States invest greater amounts. There may be a direct correlation between the amount invested and the educational results obtained, i.e. greater investment leads to better results; however, this is not always the case, as has been demonstrated over the course of this analysis.

We should also examine the relationship between education and the urban environment, in light of the influence that place of residence exerts on academic performance. To this end, it is important to note that in rural areas, "skills and human capital are generally lower" (European Commission 2006), and those who initially reside in rural locations tend to move to urban areas. In fact, in many Member States, education beyond primary or lower secondary level is more generalized in urban areas (European Commission 2006). In urban areas, almost 20% of the adult population has tertiary education, while in rural areas the proportion is only around 15% (European Commission 2006). Moreover, we should also note that the European Agricultural Fund invests less money in education and human capacity-building (Fig. 13).

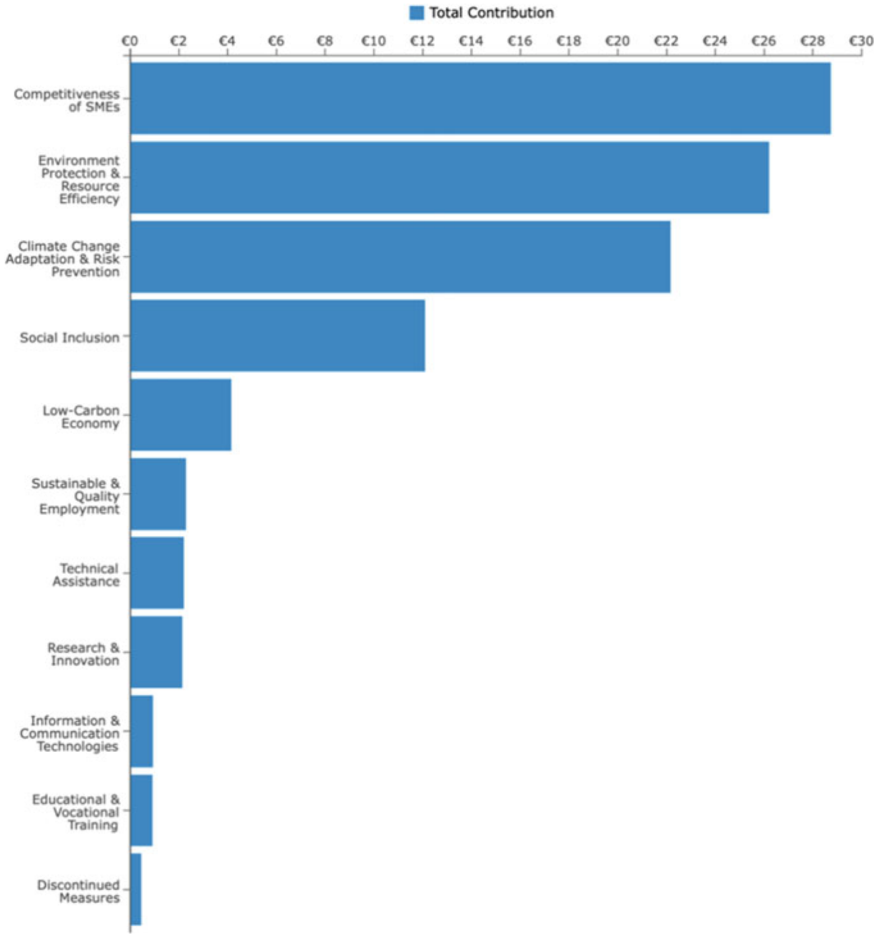

Fig. 13 ESIF 2014–2020: total budget by theme (daily update): European Agricultural Fund of Rural Development, EUR billion. *Source* European Commission (s.f.)

Taking the data presented into account, we can affirm that in order to lower the proportion of early school leavers and improve opportunities with regard to employment and tertiary education, it is necessary to invest in education. In this respect, the European Social Fund is funding initiatives to improve these aspects and ensure that young people complete their education and acquire skills that will make them more competitive in the labor market. This may be due to the fact that in 2014, 12.4% of young people were neither in employment nor in education or training; a similar figure to the percentage for 2009 and slightly lower than the percentage for 2002 (13%) (European Union 2015).

Consequently, we are dealing with people who are very much at risk of becoming vulnerable and require effective education and employment opportunities in order to ensure their social inclusion and the sustainability of our economic systems (European Union 2015). It is therefore necessary to "[tap] into alternative sources of growth such as technological innovation or advancing education and human skills, [which] could break this link by decoupling environmental pressures from economic growth" (European Union 2015, 48). Economic, environmental and social investment is crucial for supporting sustainable growth (European Union 2015).

Consequently, we can affirm that social inclusion is closely linked to socioeconomic development, and that it is necessary for countries to increase public expenditure on education in order to promote economic growth and boost productivity. Poverty, understood as a lack of access to jobs, education and health care (European Union 2015, 118), and unemployment "represent a non-realization of human capital" (European Union 2015, 115) and therefore lead to social exclusion, understood as "a process whereby certain individuals are pushed to the edge of society and prevented from participating fully by virtue of their poverty, or lack of basic competencies and lifelong learning opportunities" (European Union 2015, 118). This makes it harder for said individuals to achieve full autonomy and personal development.

Without a doubt, one of the main consequences of leaving school early for young people, as demonstrated by the data analyzed in this chapter, is the resultant difficulty in accessing employment. The lowest percentages of young people not in education, employment, or training (NEET) were recorded in the Netherlands, Denmark, Luxembourg, and Germany, while higher percentages were recorded for a number of EU countries in eastern and southern Europe. Consequently, it would appear that territory and geographical location are variables that can give rise to educational inequality. In Italy and Bulgaria, where the proportion of early school leavers is high, at least one out of every five young people aged 15–24 falls within the NEET category. However, between 2000 and 2014 this proportion fell in the majority of European countries, particularly Bulgaria, Slovakia, and Malta, where the rate dropped by more than 10 percentage points. In contrast, countries such as Cyprus, Spain and Portugal, among others, experienced an increase in these figures as a result of the economic crisis of 2008 (European Union 2015).

Europe is a rich tapestry of cultures and histories that have formed a union in order to tackle common problems and achieve common goals, without losing the cultural and linguistic diversity that characterizes the continent. European countries share many common goals, and want to offer their young people the opportunity to achieve a high level of education and training. Nobody is calling these goals into question. However, the position of these goals on the scale of priorities varies from one Member State to the next. The context of learning at different ages and different stages is not always subject to the same emphasis. Methods vary, and the processes of teaching and learning take place within different structures. Each country has its own linguistic and cultural background. These cultural models, which a priori may lend depth and richness to the EU as a whole, may nonetheless serve as factors for inequality within the EU. This much is demonstrated in the analyzes that have been carried out, in which the variable of territory, along with the variable of expenditure on education, appears to act as a marker for the inequality observed in educational attainment and school enrolment rates.

Nowadays, because the processes of change and transformation are usually viewed in systemic terms, rather than in terms of dichotomies or dilemmas (i.e., more of one thing and less of another), the concept of human development that is used as a benchmark will play a crucial role in enabling the empowerment of individuals, with regard to defining and following their own paths in order to enjoy a full life. Inequality, which cannot be explained without taking multiple factors into account, represents a roadblock to achieving the 2030 Agenda (PNUD 2019), particularly in light of the slogan "Leave no one behind" (Gobierno de España 2018). In a number of European territories, responses to the current figures for education still fall short of the desired standards, and require a holistic approach that takes the environmental, economic, and social dimensions into account.

Inclusive education means seeing sustainability as a way of life both locally and globally, where anyone can participate equally. The way of life of today's citizens must allow them to satisfy their needs, but without compromising those of future generations. They must therefore develop an attitude of continuous critical reflection so that they are aware that their actions have consequences. To achieve this, it is necessary to resort to education for sustainability, as education will provide them with "capacities (knowledge, ways of doing things and values) to have a sustainable lifestyle and to be active citizens who ensure that their governments and companies foster sustainable behavior" (Echeita and Navarro, 2014, p.149).

Inclusive education must transform education systems and other learning environments to respond to the needs of a wide range of students. Therefore, education for sustainability and inclusion must contribute to solving the (social and environmental) problem, but to do so, it needs to change "opposing school cultures, policies, and practices" (Echeita and Navarro, 2014, p.158). In this regard, Portugal, "in its latest educational reform on inclusive education, in particular Law 116/2019 of September 13" (Echeita, 2021, p.16), is an example of transition towards this process, as it responds to the needs and capacities of every single student: (1) it abandons the student classification scheme, focusing on the common and specific educational responses they may require; (2) it abandons special legislation for special learners; and, (3) it establishes supports for all learners, bearing in mind that they are part of the goals of the inclusive educational framework.

However, in Spain, Organic Law 3/2020, of December 29, which amends Organic Law 2/2006, of May 3, on Education (LOMLOE) (BOE 2020), seems to reduce the rising inequality in the Spanish education system, but it does not ensure that all students acquire a quality education, an inclusive education (Echeita, 2021). Therefore, in line with this author, some educational guidelines for equality are established:

1. Articulate school policies, practices, and educational resources that maximize the equality of opportunity for all students, with respect to their peer group.
2. Educational planning should be understood as a fundamental tool to promote actions that respond to the specific needs of students in order to help them improve their school performance.

3. Support teams must promote the learning and success of all students. They will support classroom teachers in the development, "implementation and evaluation of learning strategies to ensure the success of all students, as well as provide direct instruction to individuals or small groups when necessary" (Echeita 2021, p.17).
4. Regular educational centers must respond equitably to the needs of a wide range of students. Therefore, it is necessary to provide support staff to meet the estimated average number of students with extensive and/or generalized support needs, assuming that all students regardless of their needs have access to education.

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SDG 5. Achieve Gender Equality and Empower All Women and Girls

Recent Demographic Trends in Spanish Rural Areas: Poverty and Inequality with Gender Perspective (1999–2020)

J. Javier Serrano and María D. Pitarch-Garrido

Abstract From the 1960s to the present day, Spanish rural areas have undergone a process of population reduction and a change in their demographic structure. This demographic change is not exclusive to Spanish rural areas, but also applies to the European context. The chapter aims to provide a response to a twofold study objective. The first is to check whether the demographic and inequality trend has been reversed in Spanish rural areas. The second is to carry out a diagnosis of the state of rural areas over the last 20 years, linked to the achievement of SDGs 5 and 10. In order to achieve these objectives, the methodology used was based on the collection of statistical data on the resident population through the INE. A statistical study has been carried out using SPSS software and the graphic representation has been worked on using ARGIS 10.6 software. Moreover, the territorial scale responds to the classification by Goerlich et al. in J Region Res 35:151–173 (2016). In short, the most relevant results include the statistical relationship between population loss, sex ratio, average income, and the type of territory where the population is located. Territorial differences lead to inequalities that must be avoided and SDGs 5 and 10, which are currently difficult to achieve, must be attained.

Keywords Depopulation · Gender · Inequalities · Rural · Spanish

Spanish Rural Areas: Evolution, Characteristics and Current Situation

Spanish and European rural areas have undergone changes in socio-demographic and economic processes as a result of the rural exodus during the twentieth century

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_5

and early twenty-first century (Baudin and Stelter 2019). Rural exodus can be characterised as a systemic process with high migration rates that originates in rural areas and ends up in urban areas (Pinilla and Sáez 2017; Matthys et al. 2018). Traditionally, the rural exodus in Spain has been explained independently from the European context, as numerous authors have characterised the Spanish exodus as the fastest, longest, and most intense in Europe (Achával 1950; Aparicio and García 2016; Camarero 2009; Delgado 2018; Leco Berrocal et al. 2016; Leco et al. 2017; Palacios et al. 2017; Pazo and Moragón 2018; Rodríguez and Díez 2021; Santos et al. 2016).

However, it is a mistake to present the Spanish context as an anomaly or differentiated from the rest of Europe (Collantes and Pinilla 2020). This population flow is identified and characterised in numerous European countries, such as Germany, France, Italy, the United Kingdom, and Poland. All European countries, including Spain, have sooner or later experienced rural depopulation processes. As can be seen in Table 1, it is not true that the Spanish exodus is faster, more lasting, or more intense than in other European countries. Already in the nineteenth century, England and France showed negative variations and in the latter, the flow has been even more virulent than in Spain. It is therefore necessary to understand that Spain's demographic history runs parallel to that of Europe. For this reason, it is possible to make comparisons of the processes and it is necessary to avoid explaining that what happened in Spanish rural areas is not comparable or lacks any possible reference (Collantes and Pinilla 2020).

Rural depopulation in Europe became generalised after the end of the Second World War (Collantes and Pinilla 2020). In the evolution of the European rural population, during the twentieth and twenty-first centuries, three major phases can be distinguished, which broadly coincide with the case in Spain: 1900–1950, 1950–1990, and 1990–2021. The causes that explain each flow have peculiarities that differ between the European and Spanish contexts. It is therefore necessary to analyse the evolution of the demographic context of Spanish rural areas and to identify the

Table 1 Evolution of LEADER rural development programs at European level

	Community initiatives (CI)			Rural development programs (RDP's)		
	LEADER I	LEADER II	LEADER+	LEADER 4 axis	LEADER 2020	LEADER 2030
Period	1991–1993	1994–1999	2000–2006	2007–2013	2014–2020	2021–2027
Number of LAG's	217	906	1153	2287	2800	–
Area (Sq^2)	367,000	1,375,144	1,577,386	4,007,305	–	–
Community budget (EU) Millions of euros	416	1755	2150	96,200	100,000	95,500

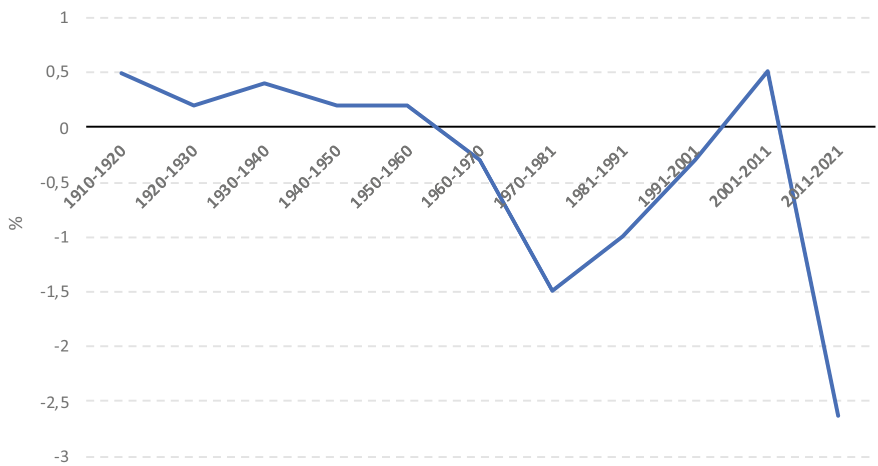

Fig. 1 Annual cumulative variation rate (%) of the population of rural Spain 1910–2021[1] (*Own elaboration from data extracted from the National Institute of Statistics*)

causes that explain the abandonment they have experienced since the middle of the last century.

In the first period (1900–1950), the rural population in Spain grew slowly, although a slight process of outmigration from rural areas began to appear as a consequence of the reduction of the working population in the primary sector and the development of industry in the country (Estalella 1983). However, the Spanish Civil War halted and/or slowed down the migratory trend and provoked a feminisation of the rural population (Camarero 1991).

The second period (1950–1990) saw the beginning of the rural exodus, which intensified from the 1960s onwards (Fig. 1), when it reached its peak with the implementation of the Stabilisation Plan (Estalella 1983; Collantes and Pinilla 2020). Migration from rural areas was conditioned by the demographic characteristics of age and sex. At first, it was marked by men, although later emigration became feminised (Camarero 1991; Roquer and Blay 2008). With regard to age, there is a bias: the young population emigrated from rural areas, which caused a generational loss (Camarero 1993). From the 1980s onwards, the process shows signs of exhaustion, with emigration losing intensity and the values being similar to the period before 1950.

The third phase took place between the 1990s and the outbreak of the crisis in 2008. The trend was reversed and rural areas (not all of them) gained population as a consequence of the demographic growth experienced in Spain between 2000 and 2008. There was talk of a rural renaissance (Kayser 1990). However, in the last

[1] Rural population data refers to those municipalities with less than 10,000 inhabitants. They are data extracted from the censuses, except for 2021, which has been from the Padrón of inhabitants.

decade, the rural population has fallen again, although to a lesser extent than in the decades prior to the 1980s (Goerlich and Mas 2008) (Fig. 1).

This process of population loss has caused demographic and economic changes in Spanish and European rural areas. Some of the most relevant problems in rural areas are: depopulation, ageing, dependency, masculinisation, lack of services, facilities and infrastructures, and among others. The rural environment is involved in what some authors call a "vicious circle" or "spiral" that continues to this day (Bielza 2010; Camarero 1993, 2003; Marchioni 1967; Rico and Gómez 2003; Sáez et al. 2001). This process consists in the fact that the initial economic and developmental weakness begin to be accentuated by the outflow of population (especially young people, women, and entrepreneurs), which causes the problems of isolation, depopulation, dependence, and loss of economic activities, with services worsening even further, so that these areas do not change their trend of decline, but evolve towards a more negative situation (Méndez 2015).

Based on this reality, which the European rural areas presented after the end of the rural exodus (end of the 1980s), the European Union began to become aware of and increase its concern for the problems shared by most of the member states in their rural areas (European Commission 1991; European Commission 2011). This was the beginning of a series of policies and initiatives at the European level that had the fundamental objective of alleviating the decline of the rural world. The rural development programs LEADER I, LEADER II, LEADER+, LEADER Axis 4, LEADER 2020, PRODER I, PRODER II, etc., are examples of this (MMAMR 2012; Network for Europe 2005; Peralta 2017; Ray 2000). The EU has invested more than 296 billion euros in the continent's rural areas; the population and territories benefiting from these programs and subsidies have gradually increased (Table 1).

The application of these programs to rural areas has resulted in both positive and negative elements. On the positive side, there is a greater awareness of the problems of rural areas among institutions and citizens, a territorial, integrated and participatory approach from both the public and private spheres (Tolón and Lastra 2007). In addition, there are numerous success factors such as, for example, the interconnection of communities, the strengthening of social networks among the population, the creation of social capital stock, etc. (Esparcia et al. 2015). Currently, Spanish and European rural areas continue to lose population, not only the smaller municipalities, but also the county capitals, and present demographic and economic problems that are difficult to solve (Collantes and Pinilla 2020; Trabada, 2020).

In Spain, the territorial result of this phenomenon is known as *Empty Spain* (a term coined by the writer Sergio del Molino in 2016), or *emptied*, a term that refers to the fact that the loss of population has been the result of the lack of a strategy to support rural areas (Molinero 2019). In order to solve these problems, Spain's Government Commissioner for the Demographic Challenge is committed to the development of a National Strategy for the Demographic Challenge, which aims to fight against the great and diverse challenges of these areas with actions such as support for youth entrepreneurship or the extension of broadband (Alario et al. 2018; MPTFP 2019a, b).

Against the backdrop of this territorial context, the world seems to be becoming aware of the ecological crisis that has been taking place for years, linked to growing and unlimited activity and consumption. The United Nations is launching a new attempt to get the countries of the world to commit to developing concrete actions for the maintenance of peace and security, in a renewed recognition of human rights. The experience gained with the Millennium Development Goals had shown that greater and clearer political support was needed. The 17 Sustainable Development Goals, consisting of 169 more concrete targets, are proposed by the UN as the core of the post-2015 development agenda. These goals and targets are ambitious and, above all, have the explicit support of most of the world's governments. They aim to transform society and mobilise people and countries to redirect investments to areas of global need by identifying economic, social, and environmental priorities.

The SDGs, approved in September 2015, make up the so-called 2030 Agenda, whose objectives are to eradicate extreme poverty and hunger, combat inequality, guarantee gender equality, fight against climate change, ensure universal access to health and education, etc. The 2030 Agenda commits all countries (195 countries have agreed to the agenda), regardless of their level of development. However, given that states have full sovereignty over their wealth, resources and economic activity, each state determines its own national goals in line with it.

In 2020, the Sustainable Development Report prepared by the SDSN (Sachs, et al. 2020) and the Bertelsmann Stiftung Foundation place Spain at number 22 (out of 166) in terms of compliance with the SDGs. In recent years, institutions have been working to place the SDGs at the centre of policies, particularly since 2018 when the Action Plan for the Implementation of the 2030 Agenda was approved.

According to the aforementioned report, Spain has relatively improved in some aspects and worsened in others. One of the formers is the moderate improvement in issues related to gender equality (SDG 5), while it has stagnated or regressed in terms of reducing inequalities (SDG 10). One of the strengths of the SDGs is that they are measurable, i.e. it is possible to use indicators to measure them, and thus to compare the process undertaken by countries. However, one of the weaknesses is that, in this comparison, internal differences, particularly territorial ones, are ignored. Geography has a long tradition of studying sustainable development and the differences associated with territorial characteristics in a holistic sense-physical, economic, social, and environmental.

In this chapter, we analyse Spain's rural areas in the light of two SDGs: SDG 5 and SDG 10, particularly the latter, given its poorer performance in recent years. The geographical literature shows that rural municipalities are not homogeneous, and do not have the same starting conditions to follow the path of integrated and sustainable development. In some of them, the context is very negative, particularly from a demographic point of view, which makes it more difficult to emerge from a situation of crisis that has been chronic for more than two decades.

Objectives and Methodology

Population is the variable that usually appears to be dependent on the socio-economic changes that occur at different territorial levels, in particular those derived from land-use policies, such as transport or the location of public services. Of course, it is also dependent on what is not produced, whether by natural or artificial causes. However, in the last five years, the demographic variable has also become a cause of socio-economic change. This is particularly relevant in those territories, the rural ones, which for decades seemed destined to be forgotten by redistributive policies in favour of other areas where the economies of agglomeration justified, and still justify, greater investments.

The loss of demographic strength in rural areas has given rise to situations of vulnerability linked to local economic crises whose greatest evidence is the closure of businesses and services. These, in turn, generate greater abandonment due to the lack of opportunities to develop a life with a future in these territories, especially in the most remote or difficult to access areas.

The variables that define a population are intrinsically related to each other and, in turn, to territorial (Fig. 2), socio-economic and political factors that are both their cause and consequence (De cos and Reques, 2019). The phenomenon of depopulation is due to demographic causes (ageing, mortality, and emigration) and economic causes (loss of jobs in the primary sector due to the mechanisation of the countryside, integration of the agribusiness value chain). On the other hand, depopulation also has demographic consequences (masculinisation) and economic consequences (abandonment of crops, loss of business) and even environmental consequences (loss of biodiversity, fires, and desertification).

In line with the above, the aim of this research is to find out whether the process of depopulation of Spanish rural areas is still active and, if so, what consequences this has on issues of inequality associated with place and gender (SDG5 and SDG10).

The diagnosis of the evolution of demographic variables in Spanish rural areas leads us to ask whether the rural development policies of the last 20 years have brought about any substantial change in these territories, particularly from the point of view of inequality and poverty over the course of this century (1999–2020), which is linked to SDGs 5 and 10.

In order to achieve the objectives, we have worked with data from the National Statistics Institute (INE), taking as a reference the period from 1999 to 2020. To this end, the data from the Municipal Register on the resident population at the municipal level have been selected, considering the following variables: sex, nationality, and age. In addition, in order to ascertain the evolution of the economic situation, economic income (average income per person and household and the average distribution of pensions and/or benefits)[2] has been considered. It should be noted that data sources for the analysis of depopulation and territorial inequality or vulnerability are

[2] The data extracted starts in 1999, except for the data on age by municipality, which is from 2002, and economic income, for which the latest data available from the INE is from 2017. There is also no data on income at the municipal level prior to 2015.

Fig. 2 Location map of Spain with topography, roads, and big cities (ArcGIS 2021)

very limited (de Cos and Reques, 2019). In Spain, there is a lack of information at the micro-scale, including the municipal scale, for key periods such as that after the 2001 census. Similarly, information on income levels and quality of life is insufficient. Therefore, we use demographic information as an approximation not only to population phenomena, but also to economic and social phenomena.

Once the socio-economic database has been created at the municipal level, a set of statistical indicators have been calculated: sex ratio, percentage of foreigners with respect to the total population, population over 65 with respect to the total population, ageing rate, dependency rate, percentage of population with pensions and average income per person and household. The socio-demographic data have been calculated for the Spanish municipalities as a whole, but with regard to the economic data it is necessary to highlight that there is a limitation, since the income indicator (person and household) and the percentage of pensions are not available for each of the Spanish municipalities: information is missing for the whole of the Autonomous Community of the Basque Country and some rural municipalities in Aragon, Castile and Leon and La Rioja.[3]

In order to differentiate the territorial behaviour of the selected variables and indicators, the classification proposed by Goerlich et al. (2016) was applied. This

[3] The current administrative division of Spain is made up of 8131 municipalities distributed in 17 Autonomous Communities and, in turn, in 50 provinces. This territorial distribution is due, lastly, to the 1978 Constitution, although it is the set of historical events that have largely marked the administrative borders of the territories.

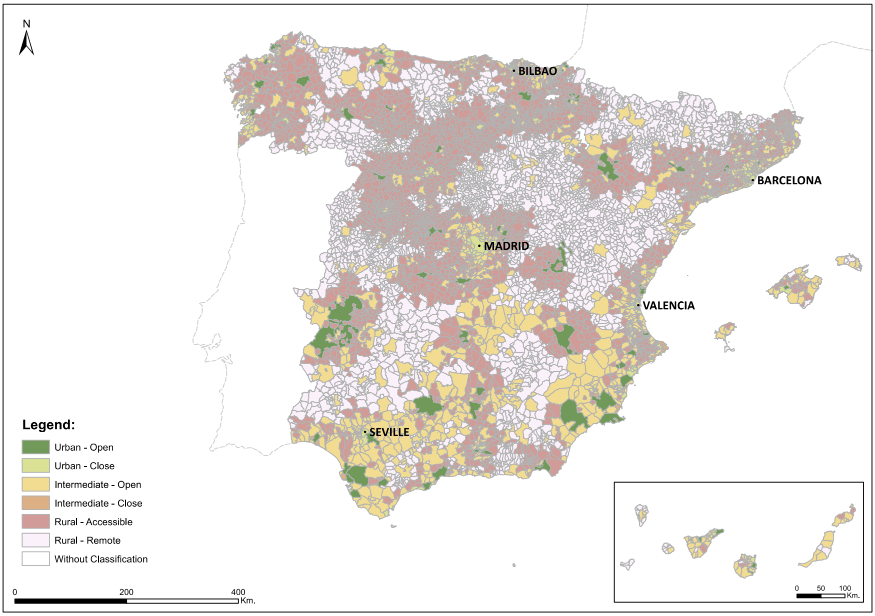

Fig. 3 Classification of Spanish municipalities as urban, intermediate, or rural (*Own elaboration from Open StreetMap Contributors*[4])

classification of Spanish municipalities is based on a set of criteria: demographics, land cover, and accessibility. This allows dividing municipalities into rural, intermediate, and urban. Firstly, the classification between urban, intermediate, and rural is determined by the proportion of the municipal population living in cells of 1 km^2. This is followed by the classification as open or closed. The difference will depend on the greater or lesser extent of natural (open) or artificial (closed) cover of the municipal territory (Goerlich and Cantarino 2013). Finally, a municipality is considered to be accessible or remote depending on its proximity to a city. The result is presented in the following map (Fig. 3).

However, in order for the results of our research to be in line with our objectives, the analysis will focus only on the municipalities classified by Goerlich et al. (2016) as accessible rural and remote rural. Both rural territories account for 34.9% and 47.8% of the municipalities in Spain respectively, i.e., in total almost 83% of the national territory. However, the concentration of population is lower than in other municipalities. According to the INE, in 2020, accessible rural municipalities would account for 9% of the total population in Spain, which is 2% less than in 1999. Meanwhile, in 2020, remote rural municipalities would account for 4% of the population of the whole country, which represents a reduction of 3 percentage points with respect to the population they had in 1999. In short, rural areas in Spain (accessible or remote) occupy most of the country's space (83%), although only 11% of the population live

[4] https://goerlich.carto.com/viz/aa0da7fc-c9d9-11e5-bc65-0e31c9be1b51/public_map.

in these areas. This explicitly represents the demographic and territorial situation in rural Spain today, where the process of depopulation in the inland municipalities still stands out.

Finally, two software programmes were used. On the one hand, *ARCGIS 10.6.1* was used for the cartographic representation of the results, especially for the socio-demographic indicators. On the other hand, the IBM SPSS Statistics software was used to analyse the data, with which the following statistical tests were carried out: Student's *t*-test and Pearson's correlation.

Results and Discussion

Many and varied analyses have been carried out on the demographic changes in Spanish rural areas, either in general or in specific regions. Most of these studies have focused on the period of greatest change: the rural exodus of the 1960s. According to de Cos and Reques (2019), the specificity of the Spanish case is that agricultural and livestock modernisation began later than in central European countries, but was more intense, i.e. more concentrated in time (the 1960s), while in the rest of Europe it lasted for more than a century. The most obvious consequence is the massive loss of population and the reduction in density in large areas of central Spain, below the critical threshold set by the EU: 12.5 inhabitants per square kilometre. This phenomenon has been consolidated so far this century, as has also occurred in other European countries, despite the enormous investments made to counteract it. The European Regional Development Fund (ERDF) regulation for the period 2021–2027 includes for the first time the consideration of population density at the municipal level, as well as the loss of inhabitants. In particular, it indicates that Member States should pay special attention to areas or municipalities with less than 12.5 inhabitants/km^2 and/or those which have lost at least 1% of their population per year in the period 2007–2017. These areas will receive funds to try to increase the attraction of investments and the maintenance of services, among other objectives.

Taking into account the 2030 Agenda (SDGs) and its long experience in rural development in Europe, the ERDF incorporates two factors that can make a difference and help to achieve sustainable development: the micro-scale (municipal) and the most current period, the twenty-first century. Both, as noted above, are the basis of our research.

We present the main results in two sections. In the first section, we seek to understand the evolution of the basic demographic variables in Spanish rural municipalities over the course of this century. Our hypothesis, in line with other research, is that the process of population loss, ageing, and masculinisation has continued and all are clearly related, although there are different behaviours depending on the type of area. Moreover, the growth of immigration in Spain is also reflected in rural areas, with differences, as in the previous cases.

In the second section, we analyse family and household income inequality at the municipal level in Spain. Our hypothesis is that, given the demographic conditions and economic evolution of rural areas over more than half a century, these accumulate a higher percentage of low-income households than urban areas. This means greater inequality and, therefore, worse starting conditions and greater difficulties in achieving SDGs 5 and 10, as will be explained in the conclusion section.

Demographic Changes in Spanish Rural Areas: Reversed or not Reversed that is the Question

Between 1999 and 2020 remote rural areas (those furthest away from urban areas) have lost 34.7% of their population (Figs. 4 and 5), while accessible rural areas have lost 3.1% of the population.

The only rural municipalities that are gaining population are those located near the country's large metropolitan areas, for example, the areas near Madrid, Barcelona, Bilbao, among others. Depopulation processes are still present in Spain's rural areas, even more so in those most affected by the exodus since the 1960s. The destination of this population leaving the villages is not so much the urban areas, which are growing, but the intermediate areas, most of which have gained around 80% more population in the last two decades.

Below we present the results of the statistical tests carried out to determine the relationship between the variables considered and the territorial typology. The aim

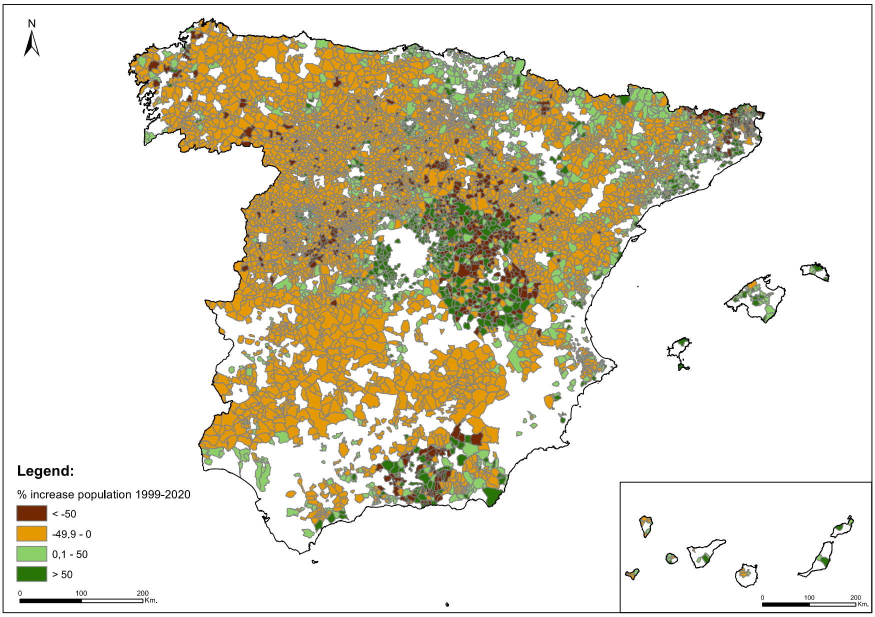

Fig. 4 Percentage of increase in population 1999–2020 in Spanish rural areas

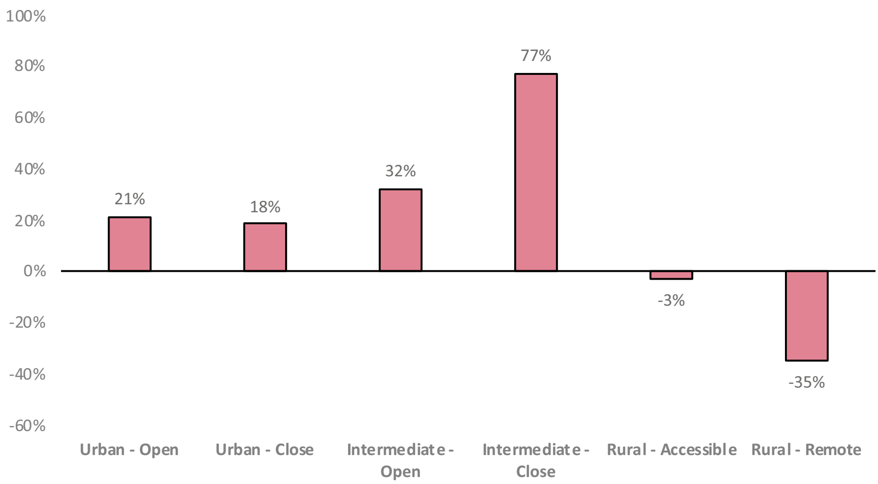

Fig. 5 Percentage of increase in population in different typology of territories (1999–2020)

is to confirm, or not, the apparent continuity of the secular trend of population loss in rural areas and its relationship to the demographic characteristics that currently define them.

Firstly, it should be noted that the relationship between the percentage increase in population during the period 1999–2020 and the typology of territory is statistically significant. For this purpose, the Student's *t*-test was applied. A quantitative variable (percentage of population increase) and the typology of the territory were available, which was simplified for the statistical analysis and only municipalities were considered as rural or non-rural. Levene's test shows that there are differences between variances (Table 3). The *t*-test gives a result of 3.575 and the bilateral significance analysis shows that there is statistical significance in the relationship between the two variables. The interpretation of the T-score is that non-rural areas have the highest population increase, while rural areas have the highest population loss. In addition, Cohen's D shows a strong relationship between the variables.

Secondly, the Pearson correlation analysis for quantitative variables carried out with the aim of determining the degree of relationship between the percentage increase in population (1999–2020) and the percentage of population over 65 years of age is significant. The result shows a negative trend, an inverse relationship between the variables, i.e. the municipalities that grow the most are those with the lowest proportion of people over 65 (Table 4). In short, the least accessible rural municipalities are those with the highest percentage of population over 65, and these are also those with the lowest percentage of population growth (Figs. 3, 4 and Tables 2 and 3).

An important part of the population growth in Spain in the last two decades has been due to the arrival of foreign populations from both Europe and other areas, particularly Latin America and North Africa. Given that most immigrants are looking

Table 2 Statistical analysis of percentage of increased population and the typology of territory

Leven (Sig)		*T*	Sig. bilateral	Average dif. (D Cohen)
0.000	Different variations	3.575	0.000	4.53
		Significant		Strong relationship

Table 3 Correlation analysis between percentage of increase in people and percentage of people more than 65 years of age in Spanish rural municipalities

		Population growth	% people 65 years old
Population growth	Pearson correlation	1	– 0.067**
	Sig. (Bilateral)		0
	N	8185	8185
% people 65 years old	Pearson correlation	– 0.067**	1
	Sig. (Bilateral)	0	
	N	8185	8185

**The correlation is significant in the level 0.001 (Bilateral)

Table 4 Statistical analysis of percentage of foreign people and the typology of territory

Leven (Sig)		*T*	Sig. bilateral	Average dif. (D Cohen)
0.000	Different variations	15.40	0.000	0.03
		Significant		Low relationship

for work, their distribution over the territory responds to the employment possibilities (and economic dynamism) of the different types of areas or municipalities.

In rural areas, a high growth rate of the foreign population has been detected so far this century, especially in remote rural areas (6.3%) and in accessible rural areas (4.95%). As can be seen in Fig. 6, this increase has not been homogeneous throughout the territory. The number of municipalities in which the percentage of foreigners exceeds 15% of the resident population has increased, although it is the more accessible rural municipalities that have grown the most, particularly those located on the Ebro, Mediterranean and/or Atlantic axes, as well as those located near large metropolitan areas. However, in the less accessible rural municipalities, the percentage of foreigners has not increased, but has decreased over the period, which is mainly explained by the loss of jobs as a result of the 2008 crisis.

In order to find out whether there really are differences between rural and non-rural municipalities in terms of the growth in the number of foreigners, a statistical analysis was carried out by applying the T student test between the variables of percentage of foreigners and type of territory. Levene's test shows that there are significant differences between the variances (Table 4). The *T*-test gives a result of 15.40 and the bilateral significance analysis shows that there is statistical significance in the relationship between the two variables. The interpretation of the *T*-score is that

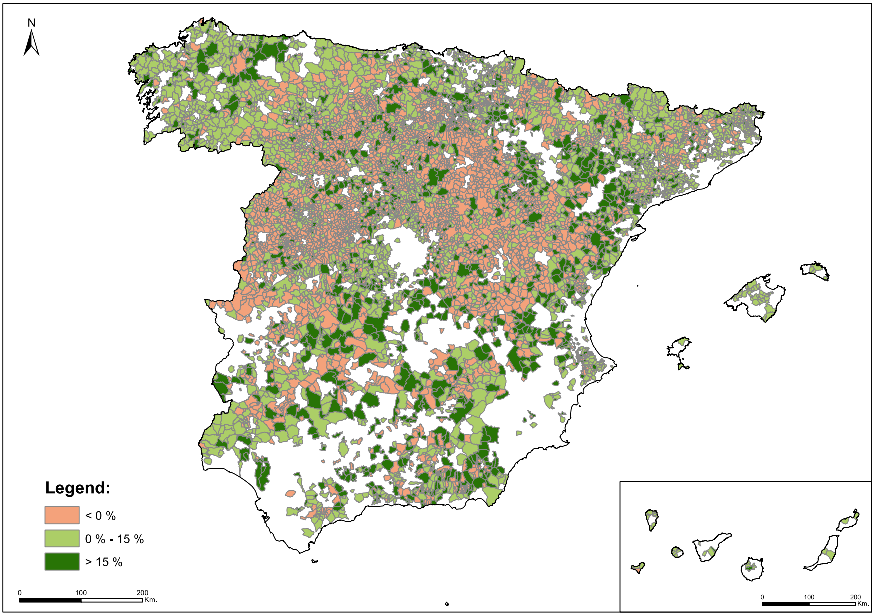

Fig. 6 Percentage of increase of foreign people in Spanish rural areas (1999–2020)

it is the non-rural areas that have a slightly higher percentage of foreign population. Cohen's D shows that there is a relationship between variables, although in this case it can be considered as a low relationship.

On the other hand, the loss of population numbers has not been gender-balanced. Women seem to leave remote rural areas in higher proportions than men, which implies a higher presence of men than women. This is particularly true in remote rural areas (17% increase in masculinisation) and, to a lesser extent, in accessible rural areas (12.3% increase), while in the rest of the areas the evolution has been towards feminisation of the population (Fig. 7). In order to test the statistical relationship between sex ratio and territorial typology, a T student statistical analysis was carried out between the sex ratio variables in 2020 and territorial typology. The result was statistically significant.

As can be seen in Table 5, Levene's test shows that there is a difference between the variances. The T-test gives a result of 6.43 and the bilateral significance analysis shows that there is statistical significance in the relationship between the two variables. The interpretation of the T-score is that rural areas have a more masculinised population, while non-rural areas are more feminised. In addition, Cohen's D shows that there is a strong relationship between variables.

Finally, it is interesting to compare the situation in the two types of rural areas: remote and accessible. As noted, demographic and socio-economic processes have not been the same. In order to detect the differences, four correlations between

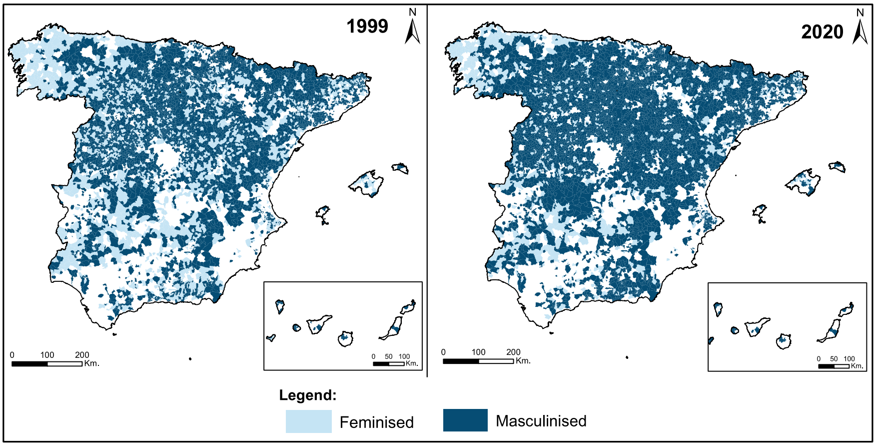

Fig. 7 Comparison sex ratio between 1999 and 2020 in Spanish rural areas

Table 5 Statistical analysis of sex ratio and the typology of territory

Leven (Sig)		*T*	Sig. bilateral	Average dif. (D Cohen)
0.000	Different variations	6.43	0.000	7.05
		Significant		Strong relationship

different indicators have been carried out, the results of which (Table 6) indicate the following assertions:

- There is a positive correlation between the sex ratio in 2020 and the percentage of people over 65 (0.362), i.e. the higher the percentage of the population over 65, the higher the masculinisation. However, in remote rural areas the percentage of the population aged 65+ has decreased by 1.7% from 1999 to 2020. This is likely to be due to higher mortality in this age group, coupled with out-migration due to lack of basic services and infrastructure.
- On the other hand, there is a negative correlation between the percentage of foreign population and the old age rate (−0.191). This means that the higher the percentage of foreign population in the municipalities, the lower the old age rate. The ageing rate has increased by 16.5% in remote rural areas and by 7.3% in more accessible rural areas, which is evidence, among other things, of a greater influx of young immigrants into the latter areas.
- However, as seems logical, there is a high positive correlation (0.88) between the dependency ratio and the percentage of the population over 65 years of age. The dependency ratio increases in those municipalities with a higher percentage of an older population. In the last 20 years, the dependency ratio in rural areas has decreased by 2.5%, especially in accessible rural areas.

Table 6 Correlations between demographic indicators linked with inequalities in Spanish rural areas

Correlation 1		% people 65 years old	Sex ratio
% people 65 years old	Pearson correlation	1	0.362**
	Sig. (bilateral)		0
	N	8185	8185
Sex ratio	Pearson correlation	0.362**	1
	Sig. (bilateral)	0	
	N	8185	8185
Correlation 2		**% foreign people**	**Ageing rate**
% foreign people	Pearson correlation	1	− 0.191**
	Sig. (bilateral)		0
	N	8185	8185
Aging rate	Pearson correlation	− 0.191**	1
	Sig. (Bilateral)	0	
	N	8185	8185
Correlation 3		**Dependence rate**	**% people 65 years old**
Dependence rate	Pearson correlation	1	0.888**
	Sig. (bilateral)		0
	N	8185	8185
% people 65 years old	Pearson correlation	0.888**	1
	Sig. (bilateral)	0	
	N	8185	8185
Correlation 4		**Dependence rate**	**% pension by people**
Dependence rate	Pearson correlation	1	0.774**
	Sig. (bilateral)		0
	N	8185	8185

(continued)

Table 6 (continued)

Correlation 4		Dependence rate	% pension by people
% pension by people	Pearson correlation	0.774**	1
	Sig. (bilateral)	0	
	N	8185	8185

**The correlation is significant in the level 0.001 (bilateral)

- Finally, the dependency ratio and the percentage of pensions in the municipalities with respect to the total number of benefits have been related. There is a high positive correlation (0.774). In 2017, the percentage of the population with pensions, social benefits, and/or unemployment benefits is higher in rural areas than in the rest of the areas. In remote rural areas, the percentage of people receiving pensions out of the total population is 32%, while in accessible rural areas it is 27.7%. In non-rural areas, the percentage of pensions is around 12%, less than half that found in rural areas.

After statistical tests, we can state the following for rural municipalities for the period 1999–2020:

- They have lost population between 1999 and 2020 (or even earlier).
- Only those located very close to large cities and metropolitan areas gain population, functioning more as part of the diffuse city than as their own entities.
- The arrival of foreigners in rural municipalities has been important, but not important enough; their presence is much higher in urban and intermediate (accessible rural) areas, while it is very low in remote rural municipalities, so this does not compensate for the loss of population.
- The population is clearly ageing, which is already a structural feature of rural areas, leading, as noted above, to a high dependency on retirement pensions.
- The rural population is clearly masculinised, especially in the more remote areas, indicating that women have left these municipalities more often than men.

All these statements, corroborated by statistical significance, have obvious consequences which, it bears repeating, seem to find a solution or at least a certain palliative, with the territorial policies developed at different levels, from the European to the local. These consequences make it more difficult to achieve the SDGs and to develop equitable and sustainable growth in Spanish and European rural areas for future generations. We will return to this in the conclusion section.

The Path to Achieving SDGs 5 and 10 in Spanish Rural Areas, Near or Far

After what has been analysed so far, it can be affirmed that the twenty-first century has not brought about a substantial improvement in development opportunities in rural areas. The inertia of the previous century and the structural changes produced in Spain and Europe over more than fifty years confirm the difficulty of redressing a situation characterised by ageing, emptying, and masculinisation of remote rural areas, all of which would not be a problem if it were not accompanied by situations of vulnerability and, therefore, inequality associated with the place of residence.

In this sense, and in order to approach this situation of inequality, the relationship between the level of personal and family income has been analysed. Given the lack of data at the municipal level for the years considered, information from 2017 has been used, despite the fact that in some regions this information is non-existent. This is an approximation that, at first glance, shows a clear territorial difference between north and south, and between urban and rural areas (Fig. 8).

In order to check whether there are significant differences between average municipal income (per person and/or per household) and the presence of population over 65 in Spanish rural municipalities, a correlation has been performed (Table 7). The result is a slight negative correlation that is statistically significant. This indicates that the higher the percentage of population over 65, the lower the average income (per person and household) of the municipality.

On the other hand, it can be observed that the highest average incomes are located in urban and intermediate areas and the lowest in rural areas. The difference between the area with the highest income (closed urban) and the lowest (remote rural) is 18.7% lower in income per person and 44% lower in income per household, indicating a very marked inequality for territories within the same country.

To check whether these differences in income by type of territory are real, a statistical analysis, Student's *t*-test, has been carried out between the variables average income (per household and per person) and type of territory (rural and urban). Both relationships are statistically significant (Table 8). It can be affirmed that urban areas have the highest average income per household and per person, while rural areas have the lowest. Moreover, Cohen's D shows that the relationship between variables can be considered very strong, especially in the case of average income per person.

Conclusion

As a conclusion of the above analysis, it should be noted that Spanish rural municipalities present serious problems related to their demographic structure, as a cause and consequence of an economic situation of crisis, particularly in the most remote areas. The gap between rural and urban areas is widening, and one of its consequences, but not the only one, has to do with the lack of opportunities that are evident in the rural

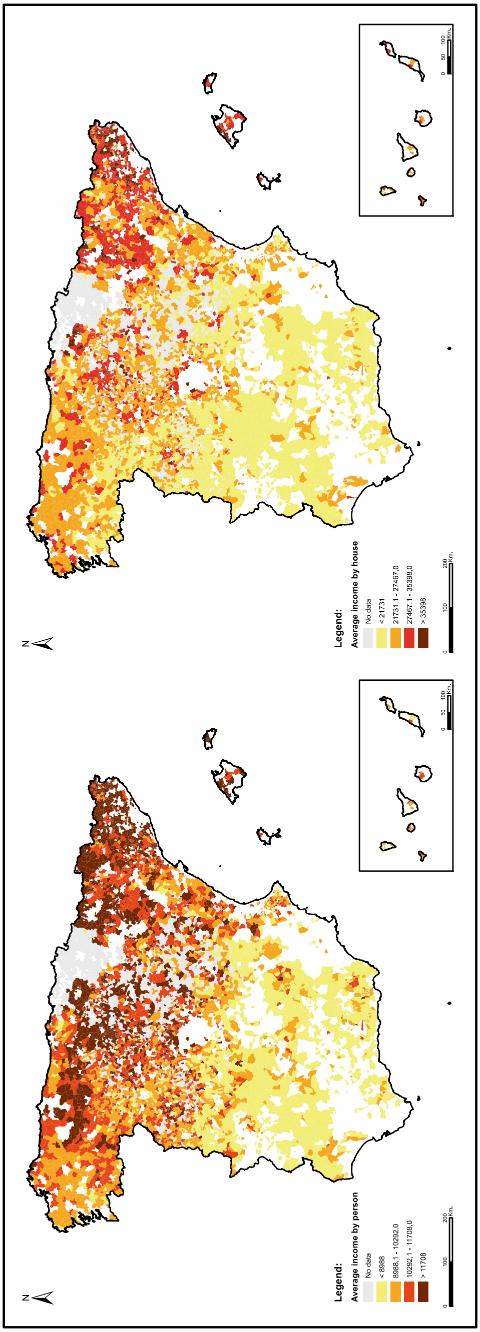

Fig. 8 Average income by people and household in Spanish rural areas in 2017

Table 7 Correlations between percentage of people 65 years old linked with average income (by person and house) in Spanish rural areas

		% people 65 years old	Average income by person
% people 65 years old	Pearson correlation	1	− 0.237**
	Sig. (bilateral)		0
	N	6294	6294
Average income by person	Pearson correlation	− 0.237**	1
	Sig. (bilateral)	0	
	N	6294	6294
		% people 65 years old	Average income by house
% people 65 years old	Pearson correlation	1	− 0.156**
	Sig. (bilateral)		0
	N	8185	8185
Average income by house	Pearson correlation	− 0.156**	1
	Sig. (bilateral)	0	
	N	6294	6294

**The correlation is significant in the level 0.001 (bilateral)

Table 8 Statistical analysis of average income (by sex and house) and the typology of territory

Average income by household and typology of territory				
Leven (Sig)		*T*	Sig. bilateral	Average dif. (D Cohen)
0.000	Different variations	24.78	0.000	7661.7
		Significant		Very strong relationship
Average income by person and typology of territory				
Leven (Sig)		*T*	Sig. bilateral	Average dif. (D Cohen)
0.000	Different variations	15.39	0.000	1752.9
		Significant		Very strong relationship

areas that are furthest away from services, which especially affects women. Being a rural woman is a clear disadvantage when it comes to building a sustainable life project for the future.

With a view towards Horizon 2030, it is necessary to implement concrete actions to reduce these inequalities. Even today, in the twenty-first century, Spanish rural areas (and also those of the rest of Europe) are far from achieving SDGs 5 and 10. With regard to the first of these, gender equality, the analysis carried out shows the result of worse living and working conditions that push people to emigrate. The presence of women in rural areas has been considerably reduced in the last 20 years, which has led to a clear process of (undesired) masculinisation of the rural world. It is clear that women in rural areas suffer triple discrimination, simply because they are women, because they are looking for a job and because they live in a rural area. The achievement of SDG 5 is still a utopia. It is necessary to stop the unwanted departure of women from rural areas, for which it is necessary to end discrimination and increase employment opportunities, moving towards real gender equality, beyond appearances.

Moreover, territorial imbalances lead to social inequalities. SDG 10, reducing inequalities, is still far from being achieved in rural areas. The high degree of dependency, linked to the over-ageing of the population, the abandonment of the smallest and most remote villages, lower incomes (largely linked to pensions), and the lack of investment in job creation are at the root of the territorial imbalance that has been demonstrated. The closure of services and the scarcity of basic infrastructures also explain the loss of population and the starting point of a spiral of crisis that is difficult to break. This diagnosis of Spanish rural areas cannot and should not be taken out of context with the challenge facing Europe, as the rest of Europe's rural areas present similar characteristics and/or problems. Therefore, it is possible to make comparisons of the processes and the situation of Spanish rural areas and extrapolate them to European rural areas. For more than 20 years, rural areas throughout Europe have been beneficiaries of European funds amounting to more than 300 billion euros, through which they have tried to reduce inequalities and put an end to serious demographic and economic problems with the application of policies and programmes characterised by the *bottom-up* approach. However, after decades of investment, and despite the benefits of the different approaches, territorial inequalities continue to exist and even worsen, generating what we can call territorial exclusion, or different speeds, which is far removed from the objectives of sustainable development.

In short, from 1999 to 2020, territorial and gender inequalities have increased in Spanish rural areas. Territories and/or regions introduce imbalances because, although the rights of all inhabitants are the same, the reality is that the lack of job opportunities, differences in income, accessibility to basic services, etc. generate inequalities that must be avoided. These countries still have a long way to go to achieve the SDGs. The territorial perspective of the targets linked to the SDGs can definitely help to reduce differences and generate greater territorial equity and justice.

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SDG 6. Ensure Availability and Sustainable Management of Water and Sanitation for All

Sustainable Solution for Clean Water (SDG6) Implemented in Ethiopia to Remove Fluoride from Drinking Water Using Natural Zeolites

Isabel Díaz, Francisco de Asís Moreno-Arangüena, José Prieto, and Rosa María Martín-Aranda

Abstract Clean water and sanitation (SDG6) are the driving force behind this book chapter. In our four-party approach, we tackle a particular problem that affects water inevitably in volcanic areas, geogenic pollutants. Fluoride is present in the rocks forming the aquifers in certain areas of the globe, which under certain circumstances leaks to the groundwaters in levels that could be harmful to human health. WHO recommends levels below 1.5 mg/l of fluoride in drinking water, yet pollution of water with fluoride does not qualify as non-potable water despite it is well known that produces a devastating disease: Fluorosis; dental and skeletal fluorosis. On the other hand, natural zeolites are minerals commonly used in water purification or even in eco-agriculture solutions. Natural zeolites are abundant and commercially available in Europe. A technology based in natural zeolites, chemically modified to selectively remove fluoride, was developed under the public–private project presented in this chapter, and further implemented in Ethiopia by an NGO (https://www.youtube.com/watch?v=w4DuIoRaaNo). Finally, diffusion and outreach activities are currently devoted to raise awareness in the society related to SDG6 in connection to other SDGs such as SDG1: No poverty and SDG5: Gender Equality.

Keywords Fluorosis · Clean water · Geogenic pollutants · Natural zeolites · Fluoride

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_6

The Sustainable Development Goals of the United Nations and SDG6

In 2015, the United Nations Organization (UN) approved the 2030 Agenda for Sustainable Development in which clean water and sanitation constitute an independent Goal 6: "Ensure availability and sustainable management of water and sanitation for all". According to UN, water scarcity affects more than 40% of people, an alarming figure that is projected to rise as temperatures do. Although 2.1 billion people have improved water sanitation since 1990, dwindling drinking water supplies are affecting every continent. More and more countries are experiencing water stress, and increasing drought and desertification is already worsening these trends. By 2050, it is projected that at least one in four people will suffer recurring water shortages. Safe and affordable drinking water for all by 2030 requires we invest in adequate infrastructure, provide sanitation facilities, and encourage hygiene. Protecting and restoring water-related ecosystems are essential. Ensuring universal safe and affordable drinking water involves reaching over 800 million people who lack basic services and improving accessibility and safety of services for over two billion.

In this context, the reuse of wastewater to recover water, nutrients, or energy is becoming an important strategy. Wastewater is increasingly being used for irrigation, which in developing countries accounts for 7% of total irrigated land. More specifically, target 6.3 of the United Nations Sustainable Development Goals sets as a target: "Improve water quality, reduce pollution, eliminate discharges and minimize the release of chemicals and hazardous materials, halve the percentage of untreated wastewater, and substantially increase recycling and safe reuse of water." The Water Economy Forum considers that three major challenges arise from sanitation management that need to be addressed: Firstly, treatment plants are prepared to treat wastewater, but they are forced to do so with contaminants from intensive agriculture, for which most are not prepared; secondly, plants are not usually available to treat persistent organic pollutants, which are experiencing a great boom, and consist of traces of products that are detected in drinking water such as caffeine, traces of medications such as ibuprofen or paracetamol, and even products for fertility treatments, of which the EU requires an increasingly demanding treatment. The third problem is storm water treatment.

On the other hand, there are voices that already speak of the impact of water scarcity on the economy. By 2030, population growth coupled with the increase in the average rate of development will cause global demand for food to grow by 50%; 45% for energy and 30% for water. In fact, it is estimated that water scarcity could cause world GDP to experience a drop of 6%. Other voices invite us to reflect on guaranteeing water security in the face of the challenge of climate change, affirming that it is already too late to protect the natural drainage capacity of the soil. In conclusion, the measures to be adopted, recommended by all the expert forums on water, focus on improving the management of water resources, increasing the use of groundwater and wastewater. Success in the reuse of water, as well as in environmental and health controls, is key in this task.

Within the actions carried out by the WHO to face the challenges around water, two relevant documents have recently been published to execute the previous strategies. On one hand, in 2009, the Water Safety Plan (WHO 2009) was introduced, which includes drinking water quality criteria to assess and manage risks in a systematic way, and more recently, the concept of Sanitation Safety Plan (WHO 2016), which provides practical guidance for the safe use of wastewater, excreta and greywater. On the other hand, in 2017 (WHO 2017), a very complete revised version of the guidelines for water quality has been published, which allow managing the risks that can compromise the safety of drinking water, according to WHO recommendations. They describe reasonable minimum requirements for safe practices to protect the health of consumers and derive numerical "reference values" for water constituents or indicators of water quality. In this report, microbiological, chemical and radiological aspects are addressed, specifying in each case the contaminants as well as their reference values, harmful effects on health, aspects of social acceptability such as smell, taste or appearance, as well as possible methods of disinfection or treatment.

The water from the groundwater represents a small part of the total water available in the earth's crust, around 0.6%, and yet it represents the main supply of water for human consumption, both in rural and urban areas, especially in less developed countries. Its chemical composition (inorganic cations and anions, and organic compounds) varies depending on its origin and determines its application in industry, agriculture or for domestic use (including human consumption). Among the chemical pollutants that naturally affect groundwater, the main ones are arsenic and fluoride, which due to their geological origin are known as geogenic pollutants (EAWAG 2015).

The Problem of Fluoride and Fluorosis

Fluorine is an abundant element in the earth's crust, occurring in soils in the range of 100–1000 mg/kg. Due to its electronegativity, and therefore its reactivity, it always occurs as a fluoride ion (F^-) in the soil, the air (as part of volatile compounds), water, as well as in plants and animals. It also exists in seawater and in a large number of foods. The sources of fluoride for the body are foods that contain it such as flour, milk, kitchen salt, shellfish or tea, but it is drinking water that contributes around 80% to the human body. In addition to natural sources, fluoride can be added to certain everyday products. Fluoride is routinely incorporated into toothpastes and drinking water in many countries, since apparently low concentrations of this element can be beneficial for oral health. The presence of fluoride in water does not alter its color, smell or taste. In the soil, fluoride is found in abundance in minerals such as fluorite (CaF_2), cryolite (Na_3AlF_6) or fluoroapatite, ($Ca_5(PO_4)_3F$). The partial dissolution of these rocks in aquifers, under certain conditions of temperature and contact time, causes contamination of groundwater water by fluoride.

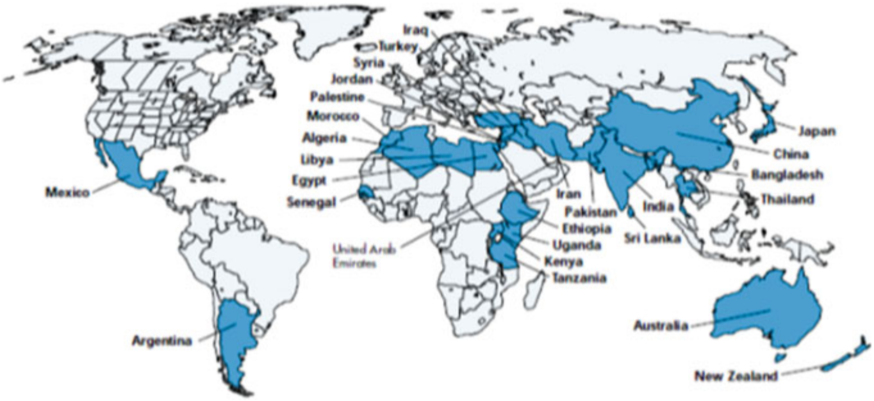

Fig. 1 Countries with endemic fluorosis due to excess fluoride in drinking water (figure adapted from UNICEF)

Fluoride is present in groundwater intended for human consumption in at least 25 countries, including Ethiopia, Kenya, Tanzania, India, Pakistan, China, Mexico or the United States (Fig. 1).

The continued ingestion of fluoride causes the disease known as fluorosis (Fig. 2), which affects the normal development of teeth and bones, whose mildest manifestation is dental fluorosis, but which generally ends up affecting the entire bone system to a greater or lesser extent (skeletal fluorosis), in which it causes serious malformations, often accompanied by alterations in other vital organs of the human body. Other symptoms of fluorosis are the thickening of the bone structure and the accumulation of bone tissue, which makes mobility difficult. Ligaments and cartilage can become ossified. Moreover, most fluorosis patients also have nausea and rupture of the membrane that covers the stomach. Fluoride can also damage the thyroid gland, giving rise to hyperparathyroidism, related to a secretion of parathyroid hormones, which regulate the concentration of calcium in the body. Skeletal fluorosis causes malformations, back pain and stiffness, as well as neurological deformities. For this reason, the WHO has established a maximum limit of 1.5 ppm in the concentration of fluoride in water intended for human consumption. However, this limit is widely exceeded in most of the affected regions of the world, being estimated that between 300 and 450 million people are exposed to fluorosis.

The Solution Based on Natural Zeolites: A Technology Transfer Journey

Various technologies have been tested for the removal of fluoride from drinking water up to the limit established by the WHO. However, and despite the great efforts and investments applied, there is no methodology widely accepted by the different

Fig. 2 Dental and skeletal fluorosis (images taken by the authors in the Ethiopian Rift valley)

countries. Existing technologies include (i) precipitation-coagulation methods, (ii) membrane-based processes, ion exchange methods, and (iii) adsorption methods (Jagtap et al. 2012). Precipitation-coagulation methods trap dissolved contaminants into insoluble solids. The process usually uses pH adjustment, addition of a chemical precipitant and flocculation producing large quantities of waste that need to be managed properly as becomes extremely harmful for the environment. Membrane-based process, such as reverse osmosis, is based on the presence of semipermeable membranes that are able to remove efficiently every pollutant yet they are energy demanding, skillful personal demanding, and once again generating a waste that requires proper management. An additional drawback of membrane-based technologies relies on the lack of selectivity in the removal process, where harmful but also beneficial minerals are removed from the water for human consumption. Adsorption methods imply that fluoride is removed by ion exchange or surface reactions. In choosing the adsorbent, it must be considered that the adsorption process may depend on the pH, and on the presence of other anions common in groundwater such as sulfates, phosphates or bicarbonates that can compete with the removal of fluoride. Likewise, the adsorbents need to be regenerated, or reused once it is saturated with fluoride.

The objective is to use cheap adsorbents, in our case based on natural zeolites, that allow the development of technologies with low environmental impact and minimum maintenance needs or managing skills, making them easy to implement in developing countries.

Zeolites are natural minerals formed over millions of years by the pressured contact of volcanic eruptions. Zeolites are a vast natural resource in Ethiopia and in Europe (Wise 2013). In particular, in Ethiopia, the presence of fluoride and zeolites may be geologically related as both have volcanic origins (Fig. 3), however, the lack

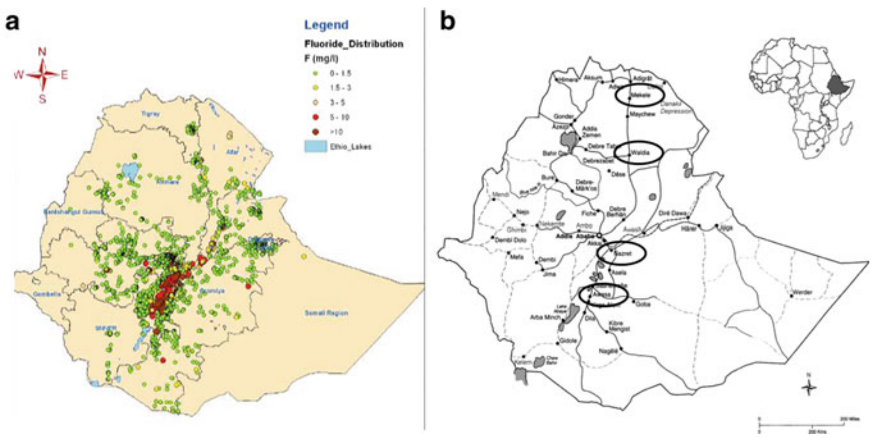

Fig. 3 **a** Fluoride concentration distribution in groundwater in Ethiopia own work. **b** Natural zeolites locations in Ethiopia adapted from Melka et al. (2010)

of systematic investigations of the occurrence of natural zeolites in Ethiopia implies that other sources have to be explored.

Anyhow, our scientific cooperation produced an investigation of zeolites from the northern part of Ethiopia revealed good quality stilbite, as well as analcime and mordenite (Gómez-Hortigüela et al. 2013). Later on, it was developed a chemical modification on the above mentioned pure stilbite leading to a highly efficient fluoride adsorbent (Gómez-Hortigüela et al. 2014a, b). This work was protected under an international patent (Gómez-Hortigüela et al. 2014b).

This is the beginning of the story narrated in this book chapter. The four inventors in this patent are three from the Spanish institution ICP-CSIC, and one from the Ethiopian Chemistry Department in Addis Ababa University (AAU). AAU had no experience in Technology Transfer as an Institution back then, so it became the first patent of AAU as an Institution (El País 2013). This fact was both a challenge and an opportunity. The challenge was to the Vice-presidency of Technology Transfer of the CSIC who had to lead the process with a partner that had no experience in the different steps involved in intellectual property protection process, however, the trust generated between institutions given by the presence of the research team of the ICP-CSIC on research leave at AAU, help build the bridge to overcame these problems. Finally, the success was acknowledged by the national press, not only in Spain but also in Ethiopia and other African Countries. The Spanish Embassy to Ethiopia used this new joint patent as an advertising tool to enhance the institutional relationship in what we believe is an experience of Science Diplomacy. The main reason to be proud exploited by the ambassador was that despite the millions of euros invested in Ethiopia by many countries and international development agencies of the wealthiest economies, it was the first example of a scientific invention produced out of a development cooperation under universities, or higher education institutions, that led to a potentially commercial product. This Science Diplomatic effort yielded as a result that the technology was advertised and thus, awoke the interest of several companies involved in water technologies. The journey of the Technology Transfer began (WIPO 2020).

After a lengthy and tense process of discussing a negotiating with all the companies interested in the new technology, TAGUA SL, a Spanish company based on Tenerife, acquired the technology through a license agreement. Between 2014 and 2017, TAGUA SL, aware of the problem of the excess of fluoride in groundwaters suffered in their own land (Plan Hidrológico de Tenerife 2015), invested in the research team of the ICP-CSIC to develop a commercial product, and finally in April 2017, the new factory opened production of a newly generated commercial product: HINDROP (https://hindrop.com/). HINDROP is a new material for the removal of fluoride in water for human consumption, based on natural zeolites. The new material is more efficient, cheaper, does not generate waste, does not require trained personnel, or complex infrastructure, allowing its use in both domestic and collective solutions.

Once the product is commercially available, the first barrier for implementation of the technology is already overpassed, sustainability of the filter. The next natural step for us was finding a way to demonstrate that the technology works in rural areas of the Ethiopian Rift Valley, those areas where we came across the problem of fluorosis.

Finding the right location for this purpose was the next stepping stone. Our aim was from the beginning to include our technology in the agenda of the Ethiopian Ministry of Water under the Fluorosis Mitigation program funded by UNICEF (Datturi et al. 2015). However, coming from a scientific collaboration, the path to penetrate in the international development agencies arena was another challenge. We needed an evidence of its performance for the stakeholders to accept our technology, we had to find the right location ourselves, and here is when the networking among the Spanish actors in Ethiopia yielded good results. A Spanish person working at the Italian Salesians Mission in Ziway (central Rift valley) introduced us to the perfect collation. More importantly, the courage of the NGO-ADS present in Ethiopia in the sectors of water and health bridged this new challenge. Finally, the two organizations: NGO-ADS and ICP-CSIC teamed up for the implementation process in two schools belonging to the Salesians Mission in the Ziway area (https://www.defluoridationethiopia.com/).

The scheme of the purification plant is simple (Fig. 4), it consists of a storage tank for the water extracted from the aquifer by solar-pumping, and two tanks filled with the adsorbent, through which the water is passed and by simple contact, at its outlet it is stored as drinking water.

It is a known system in Ethiopia, accepted and implemented by the Ministry of Water and Energy (Datturi et al., 2015). In this community, there is no charge for drinking water from the wells, contrary to what is common practice in government wells. After the natural zeolite-based adsorbent is spent, the fluoride concentration in the spent adsorbent is in the range of 400–600 mg/kg, lower than that of the surrounding soil (which is more than 1000 mg/kg). Therefore, the exhausted material could also be used to improve the quality of the soil for its use in agriculture. The fluoride in the spent adsorbent is tightly bound to the adsorbent, just as it is trapped in the bones causing irreversible disease, and therefore cannot be leached into the soil.

Fig. 4 Treatment plants using zeolite-based technology in two schools of the Salesians Mission (Don Bosco) in the area of Ziway, the central Ethiopian Rift valley

Thus, added value is given to the waste, avoiding the regeneration cycle which, in the case of developing countries, is a new source of contamination of subsoil water. But this is phase II of the project (https://www.defluoridationethiopia.com/events), still under investigation.

The Bumpy Road of the Implementation in Ethiopia

One may think that the implementation of a new technology is very easy. We can see daily how we accept easily the new technologies when we are using new computers and new telephones, for example. Most of the time, we cannot understand these technologies, although they are very friendly. But when we are in front of a technology that we cannot see with our own eyes, the difficulties start to be present, and if you are trying to implement it in developing countries, the difficulty increases considerably, as it has happened in this case.

In theory, the innovative system works as it is indicated in Fig. 5. It consists of a storage tank for the water extracted from the aquifer by solar-pumping, and two tanks filled with the adsorbent, through which the water is passed and by simple contact, at its outlet it is stored as drinking water.

The background of ADS NGO is broad: more than 15 years implementing projects in Ethiopia and more than 17 years raising public and private funds. Our experience on the field has been key to achieve this particular project to improve the lives of many people affected by the fluorosis.

The implementation of the project on the field has been full of all kinds of difficulties: financing problems, design and construction of the water treatment plants and security situation on the area were some of them, adding the usual and unusual paperwork needed to implement a project in Ethiopia.

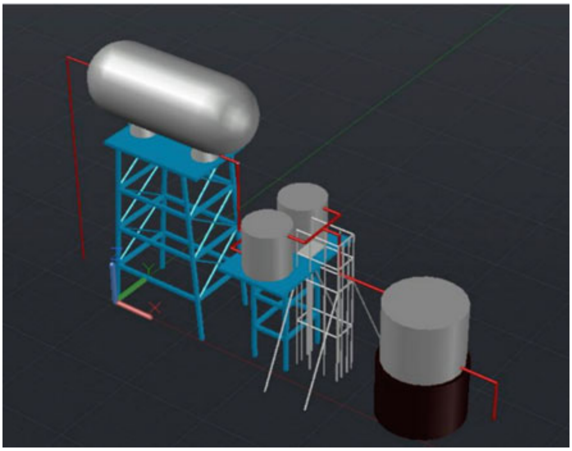

Fig. 5 Scheme of the treatment plant, improved by Ignacio Peñalba Perdices in his Msc Thesis carried out under the framework of our project and was defended at *Escuela Técnica Superior de Ingenieros Industriales, Universidad Politécnica de Madrid* in February 2022 (public at: https://oa.upm.es/70143/)

Private and/or public funds: In the timeline, our first difficulty of the project was getting a donor that supported science and humanitarian cooperation walking together in a project, a donor that believed in the idea, based on our experience, our knowledge about the country, the institutions, and the governmental partners. Given that the idea deals with Innovative Solutions for Developing Countries, in a first attempt, we applied to the Spanish Cooperation Agency (AECID) to the Innovation funds for Cooperation, that we thought very adequate to our project. In a first grant, on 2018, we couldn't pass the initial threshold, ranked very low compared to other competitors.

In a second chance, one year later, our project received better evaluation, but it was missing 0.01 points to be eligible. After these results, we realized that we need to find other ways to get the proper funds to implement this project and we got it. It was a social Swiss bank through a personal contact: Stiftung Freie Gemeinschaftsbank that have a similar history in the foundation of our NGO, finally the team ADS and ICP-CSIC raised the total amount of 116.600 euros. These donors provided the necessary amount to implement the phase I of the project: building two treatment plants. However, this money has to reach Ethiopia, and in order to do so, we initiated a new difficult task, signing the project in Ethiopia with the Ministry of Water and Energy so we can officially use the funds there. This process has been a long one full of ups and downs.

At this point, it was very helpful that this patent was produced in collaboration with Addis Ababa University (Chemistry Department), and thus, it had the full support of the Ethiopian and Spanish Higher Academic Institutions, including the Ambassador of Spain to Ethiopia gave a press conference together with the Vice-President of AAU to announce the new patented technology. Thanks to this strong institutional collaboration, we were present in the local newspapers giving us the accredited business card as a new technology approved by Ethiopian institution.

The first proposal was submitted to the Ministry of Water and Energy (MoWE) with only 60% of the required funds to implement the project. We requested the Finance and Defluorization departments of the MoWE the remaining amount of the project. To our surprise, they accepted the proposal including the 40% funds provided by them. Our joy was finished the same day that we signed, because it was this very same day when they realized that the MoWE still counted on us to add the remaining 40% of the money. Our project was alive for only one day.

In the meantime, and after failing for the second time (and 0.01 points) the funds of AECID-INNOVACION, we got finally the 40% remaining money from a private Foundation Juan Entrecanales de Azcárate to start the phase I of the project and the construction of the treatment plants. At this point, we rearrange the proposal and the budget of the project with the MoWE. And it was in this moment when we got the special support from the Minister and the State Minister that were very enthusiastic with the project because he was well aware of the fluoride problems in the Rift Valley. Thanks to this support we got the acceptance from the MoWE in a short period of time when they realized that we are going to provide the 100% of the project too.

With the acceptance on our hands, the next step was the preparation of the bid to get the proper constructor to build the water treatment plants. As new technology system of filtration but at the same time close to the other system of filtration, we requested a constructor specialized in similar water treatment plants. Having this consideration, we got a local constructor, and we started the first test of the technology under real parameters. The initial plan to finalize the construction in only six months, just remained as a dream plan because the security was affected in the project area. Many conflicts happened: fight between different ethnic-clans and displacement of people.

During this particular year, 2019, Ethiopia received 4 million displacement all over the country. The construction was delayed for more than 6 months. Once the construction of the water treatment plants was finished, importing the zeolite-based adsorbent became an issue. The container from the factory in Tenerife (Spain) arrived at Ethiopia with the surprise that the original duty free of the items was canceled adding an extra cost of 18.000 euros on duty tax. It has to be remarked here that the MoWE provided a supporting letter to get the adsorbent duty free, but this letter was refused from customs authority. There was only one way out, pay the taxes and continue with the project. In fact, we proceeded to a final check-up of the entire facility while loading the adsorbent in the system and new problems related to the design and the construction arose. Only the help and commitment of all the individuals coming from TAGUA S.L., the ICP-CSIC team and the NGO-ADS personal, everything was solved on time before the day of the inauguration.

The inauguration day was a total success (Fig. 6). We were in the Ethiopian television (https://www.youtube.com/watch?v=U4IvgeGpcig), in the national newscast, and in many international media (https://www.defluoridationethiopia.com/inauguration). The population in the area where very happy about this new implementation. In Obe, we replaced the traditional manual water pump for a solar pump with the idea to have a fully sustainable project. (Dida at this time had a similar system). The Salesians community provided with full support during the entire project on the two schools where we implemented this technology based on zeolites.

It was really rewarding listening from the voice of an old woman, with more than 75 years old, that after the installation of the solar pump she became fully independent, she doesn't need to ask for help to handle the water pump while filling

Fig. 6 Photo of the inauguration day with the Spanish Ambassador in the center together with the Head of the Salesians Mission in Ziway and the Vice-President of Technology Transfer of the CSIC, the CEO of TAGUA, other authorities, and the ICP-CSIC and NGO-ADS teams

her own small jerrycan. The test couldn't be more satisfactory, the first sample of treated water treated on field was totally fluoride-free.

In this context, the connection of our initial objective focused on water, SDG6, connected directly with other objectives such as SDG1: end of poverty and SDG5: gender equality. Demonstrating that mainstreaming of objectives is the key for success in any science and technology development.

Second Phase and new donor: After the impact in the media and with the first results, new donors joined our project such as Fundación General CSIC, and together with a second round of funds from the Foundation Juan Entrecanales de Azcárate, encouraged us to apply again to AECID-INNOVACION to continue with the improvement in the implementation of the innovative projects on field. This third time we were successful, we launched Phase II of the project.

During the construction of the water treatments plants and the loading process of the zeolite, we realized that the design could be simplified and improved. This was one of the main targets in the second phase, but the most important one was the reuse of the adsorbent after it was completely saturated, fulfilling our commitment with sustainability by producing a zero-waste technology. To achieve this target, we needed to prove that the zeolite can be given a second use in agriculture without producing further harm to the soil nor to the plant. For these studies, we involved Haramaya University in the project as a local partner expert in Soil Chemistry, to prove it.

The first results of the new phase arrived just a few days ago and the initial results of trials are very promising, and it is a work in progress.

The Role of Commitment and Interaction Between the Different Actors

According to our experience, we can conclude that the commitment and the interaction of so many different actors are essential for the success of a case like this (Moreno Aranguena 2022). We have witnessed that without this interaction, without partnership (SDG17), there are crucial flaws in the interfaces of the SDGs.

All the works performed on the field would not have been possible without the help and trust of many people. In Europe, the donors supporting us with full confidence in the project and in the implementation showing flexibility to the difficulties in the execution the project. The support from the Ethiopian Government, from the moment of filing the patent to the MoWE, not only at Minister and State Minister levels but the Finance department head, and the Water Supply department head also given to us the confidence and the support to get the final agreements to implement the project. This confirms that in the implementation of the projects on the field as much the Governmental support and as the personal implicated are key part in the implementation of any development project.

A key part of the project is the day by day follow up by the Salesians personnel on the field, the beneficiaries. The feeling of belonging to the team, together with the ownership of the technology from day one, has been essential in all the activities including following and collecting samples and data of all beneficiaries of the area.

Currently, the water supply in the area is very low. The other existing water wells of the area are broken, and the beneficiaries of Obe, one of the water treatment plants has been increased from 400 people up to 3.000 people. This can be a new challenge for the project and for the installation and it will be for us a stress situation of the water treatment plant that can provide us extra data about the fully usage of the installation on the field.

Looking back, the project from the beginning it was a very long process not only in Ethiopia but also in Spain with the financing seeking, the activities on the field, etc., but at the end, there is a result and we are very proud to be part of this different implementation of a development project.

This project proves by itself the importance and the complement of the different type of actors in a development project. On one side, a scientific institution as the CSIC, where many scientists are working to solve problems that are affecting us daily. On the other side, the involvement of the private companies that assume the risk to implement new technologies and invest in the development of new products. Others as the NGOs, as ADS, that we know how to implement this new technology using our expertise on the field. And all of these couldn't be possible without the involvement of the educational institutions that contributes to the society, such as Spanish National

Distance University (UNED), supporting the awareness, the dissemination of the conclusions and the experience of the projects to improve the lives of many people that can be affected by the consume of water with high levels of fluoride on the water.

We believe that the use of this technology to improve people's living conditions must have universal access, so one of the activities that we consider necessary for this is to share the knowledge and results of all the actions that we have taken developing on the ground. Diffusion and outreach activities are currently devoted by the new partnership created between the NGO-ADS and UNED university, to raise awareness in the society related to SDG6 in connection to other SDGs such as SDG 1: No poverty and SDG5: Gender equality.

UNED university is a vehicle for the transmission of knowledge, blending research, with technology transfer, dissemination, and international cooperation. Dissemination is made by a series of exhibitions at UNED university Associate Centers all over Spain (it has a total of 62 associate centers). These exhibitions explain and raise awareness on the fluorosis in water problem through a collection of photographs at multiple locations in Ethiopia. Photos that illustrate the challenge of water availability and the challenge to travel on foot many kilometers to obtain water daily. This role is typically made by girls who spend the day on this activity, while boys stay and go to school. Bringing water to these remote locations and purifying this water is not only a critical need for rural Ethiopians; it is also the best way to ensure integration of girls into the education, thus fostering their personal development. These photo exhibits a way to promote awareness and rise crowd funding to support the construction of wells and purifiers across rural Ethiopia. This mission, bringing more than simply water, does not stop at educating girls, and it is further complemented by a grant program that brings women to UNED university departments in Spain to get trained in scientific research. This is done through the Fundación Mujeres por África (Women for Africa), whose first awardee from Haramaya University, Ethiopia, went to the Department of Inorganic and Technical Chemistry, at UNED university in Madrid, Spain.

In addition, through the proper use of social media, Kokebe application (https://web.adsong.org/kokebe/), an Ethiopian name that means "star", and which is an application made by NGO-ADS aimed at schools, in which we want to stress the importance to have drinking water and the problems that exist in developing countries due to the scarcity of drinking water and how SDG6 is related to SDG5 because girls are the ones who cannot attend school to fetch for water every day.

CSIC and UNED university coordinate with Colarte (https://www.colarte.org/) to disseminate this at schools all over Spain (Fig. 7).

The access to education, the improvement of water quality and capacity building at all levels of society, is going to be one of the line of actions if we want to succeed in SDG1 and SDG5 to advance, both on an egalitarian level within society and at the level of its global development.

Fig. 7 Photo of the open ceremony of the photo exhibition and Kokebe activity at Galapagar, Madrid

Acknowledgements This work was funded by the Spanish Agency for International Development Cooperation AECID INNOVACION (2020/ACDE/000373). Luis Gómez Hortigüela and Joaquín Pérez Pariente are also acknowledged. Authors thank Vice Rector for Research, Knowledge Transfer and Scientific dissemination of UNED university the support of Ethiopian picture exhibitions and Funds for Nejat Redwan Habib through Mujeres por África Foundation (www.uned50.es). Authors also thank the association www.colarte.org for the cooperation in the dissemination of the results of this project in the Society. Authors also thank the NGO www.adsong.org the total support during the progress of the project.

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SDG 7. Ensure Access to Affordable, Reliable, Sustainable, and Modern Energy for All

Improving Eco-social Literacy Using Spanish Media Coverage of the EU's Clean Energy Strategy

María-Luisa de Lázaro-Torres, Miguel-Ángel Puertas-Aguilar, and Javier Álvarez-Otero

Abstract Sustainable Development Goals represent a collective effort to achieve a better future for the world. Specifically, a clean energy transition requires eco-social literacy to improve in relation to Sustainable Development Goal 7: to ensure access to affordable, reliable, sustainable and modern energy for all. Thus, it seems appropriate to clearly identify the key concepts that everyone should know in order to efficiently make the clean energy transition. The method employed in this study to introduce citizens to the topic has drawn on Spanish press coverage on clean energy over the last two years. MyNews data base, a digital archive of modern printed press in Spain, has provided us with access to 66 different journals to identify 'clean energy key words', and the information obtained has been cross-referenced with BBC web page information, the New York Post, Washington Post and various European Union and International Energy Agency reports, among others. Thus, it has been possible to observe how the European Union's (EU) is leader on environmental, technological, investment and employment actions on clean energy transition. The two key questions to collect main concepts from the press have been: has the socio-economic effort been sufficient? And: what are the main challenges for a clean energy transition? The response has included reference to the latest EU regulations and the relevant emerging debates and controversies. The main themes that the press have addressed included the problem of renewable energy storage, how to obtain energy from what used to be waste (such as poultry manure or brine from the desalination of seawater), how to favour the circular economy, and other experimental initiatives, such as biopropane production and decarbonization in the tertiary sector (tourism

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_7

and transport). This paper also asks whether clean energy can be a good option for decarbonization in the context of growing energy poverty. Taken together, this information made it possible to pin down the main concepts required to train citizens in eco-social literacy and to weigh up its pros and cons in an informed way.

Keywords Geography · SDG7 · Energy transition · Clean energy · Decarbonization

Introduction

The world has an energy deficit. There are areas that still do not have access to modern electricity, affecting 759 million people in 2019; three quarters of whom live in sub-Saharan Africa (United Nations 2021). While the world is moving to adopt clean, renewable energy sources, many people in developing nations still struggle to obtain access to reliable electricity and safe cooking and heating fuels. (https://www.bbc.co.uk/bitesize/guides/zffqjsg/revision/1). This energy deficit, still experienced in many areas of the world, means that energy consumption continues to increase globally.

Sustainable Development Goal 7 (SDG7) advocates access to modern energy for all that is affordable, reliable and sustainable (Table 1).

To achieve SDG7, it is necessary to redouble efforts to accelerate energy efficiency and renewable energy actions, especially in the heating and transport sectors (UN 2021). However, in the EU, the efficiency brought about by technology and energy saving policies designed by governments might reduce consumption, and contribute to the energy transition, i.e. the progressive abandonment of fossil fuels and their replacement by clean energies.

Clean energy technology is becoming a major new area for investment and employment–and a dynamic arena for international collaboration and competition. The term 'clean energy' incorporates different dimensions (International Energy Agency 2021):

(a) In power: generation from renewable sources, nuclear and fossil fuels fitted with carbon capture, utilization and storage (CCUS); battery storage; and electricity grids.
(b) In efficiency: efficiency in buildings, industry and transport (excluding aviation bunkers and domestic navigation).
(c) In end-use applications: direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; use of hydrogen and hydrogen-based fuels; CCUS in industry and direct air capture.
(d) In fuel supply: in, for example, low emissions.

The possibility of reducing greenhouse gas emissions has been boosted by the drastic decrease in energy consumption during the COVID-19 period, especially in transport. To this end, the EU is creating funds for post-pandemic economic reconstruction with a clear focus on the renewable energy sector (Diario de Noticias, 14/02/2021), such as the Next Generation EU (NGEU) fund. These funds seek to

Table 1 Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all: goals and indicators

Goals and targets (from the 2030 agenda for sustainable development)	Indicators
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Proportion of population with access to electricity
	7.1.2 Proportion of population with primary reliance on clean fuels and technology
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in total final energy consumption
7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and landlocked developing countries, in accordance with their respective programmes of support	7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)

Source Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. E/CN.3/2022/2 (United Nations 2022)

contribute to the shift from decarbonization to clean energy (La Voz de Almería, 9/06/2021), thus promoting the energy transition process. In this context, the reduction of greenhouse gases (carbon dioxide, methane and nitrous oxide, among others) is aimed at slowing climate change.

One way of measuring this achievement is via target 7.2: by 2030, increase substantially the share of renewable energy in the global energy mix. The S&P Global Clean Energy Index since 2007 has aimed to track companies that produce energy from solar, wind, hydro, biomass and other renewable sources, as well as companies that build and provide clean technology to measure the performance of companies in global clean energy-related businesses from both developed and emerging markets (S&P Global Clean Energy Index 2022). This Index comprises around 100 energy groups with environmental and sustainability criteria, which investment funds use to create their investment portfolios. Being part of the Index automatically means more 'upside potential' on the stock market, so any change in the index conditions the companies in the sector, which struggle to achieve certain parameters aimed at improving transparency. The methodology includes market trends and sustainable investment standards in order to be, and remain, among the companies considered in the Index (Miguel Ángel Patiño, Expansión, 21/10/2021). Thus, many companies within the Index, such as Italian Enel, French Engie and Spanish Iberdrola have experienced unprecedented stock market increases in recent years (Domínguez 2022). This competition to be part of the Index in itself contributes to a further reduction in the carbon footprint.

This Index, in addition to being very high in the middle of the pandemic, became very popular, and led to great interest in social media, especially in Switzerland, Italy, Germany, the UK, Canada, USA and Australia, according to data from Google Trends, as shown in Fig. 1.

The promotion of renewable energy sources is essential in the energy transition, but on the other side to the coin would be asked: Is it possible to only use renewable energy or are other energies labelled as 'clean' also good for decarbonization? Additionally, there is a growing problem of energy poverty emerging in the EU.

Thus, the discourse generated in relation to the energy transition in the press between 2020 and the beginning of 2022 has been the subject of this work, which aims to select the most important concepts that appears on press for eco-social literacy that all citizens should know in detail and the controversy about the clean energy concept. And in addition, how the various alternatives for achieving the energy transition appear in the press media. It deals with how energy-related issues and the ongoing energy transition are communicated in the press.

Together, all this information enabled us to identify the main concepts required to train citizens in eco-social literacy using relevant, detailed and balanced content.

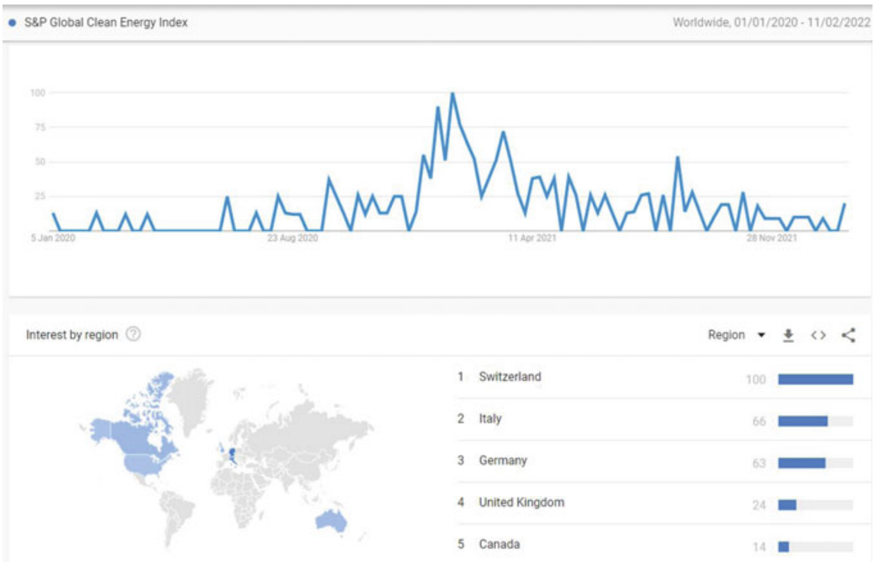

Fig. 1 Popularity of the S&P Global Clean Energy Index in Google search across the world, from 1/01/2020 to 11/02/2022. *Source* Google Trends (https://www.google.com/trends)

To this end, articles in the Spanish press on the increase in clean energy and related policies in the EU have been analysed. This information will be contrasted with various international media and different international reports that specialize in the subject.

Methodology

This study reviewed all the information related to clean energy from a selection of mass media to determine the current situation and identify the key related concepts that all citizens should know.

The information from the Spanish press was obtained from the MyNews database, from which, after a search for the term 'clean energy', the 95 articles that raised this topic in the context of the EU were selected. This involved examining over 66 different newspapers for a few months in each of the following years: 2020, 2021 and 2022.

This has been contrasted with information available from the BBC in the UK, where the key word searches have been 'clean energy' and 'renewable energy Europe', which refer to the EU. The Washington Post and The New York Post newspapers have also been analysed in a similar way, where the key phrase was: 'clean energy Europe'. These searches yielded the results shown in Table 2.

On this basis, the information was compared with reports from the EU and the International Energy Agency, among others, in order to obtain a global vision of EU policy in relation to clean energy and the most commonly used concepts that we consider to be of interest in terms of citizens' eco-social literacy.

Table 2 Data sources

Source (key words used in the search)	Years	Number of clean energy news articles (EU topic)
Spain's MyNews (clean energy)	2020 (October–December) 2021 (January–December) 2022 (January–February)	97 (32) 197 (33) 129 (30)
BBC (clean energy/renewable energy)	2020–2021–2022	290 (14)
New York Post (clean energy Europe)	October 2020–February 2022	341
Washington Post (clean energy Europe)	October 2020–February 2022	515

Results and Discussion

The energy transition is increasingly important in many European countries (e.g. Austria generates 79% of its energy from renewables, and Denmark generates 78% (La Vanguardia, 25/01/2021). For Spain, the figure is 43.6% in 2020 according to Red Eléctrica Española (REE) (El Economista, 27/05/2021). Germany is split between the Ruhr area's required energy transformation (BBC, 04/01/2020), and the need for all gas stations to also offer charging stations for electric cars (Washington Post, 11/02/2022).

In this research, the importance given in the most developed countries to zero emissions (which is the first step towards achieving SDG indicator 7.2.1: Renewable energy share in the total final energy consumption), stands out. To this end, new EU regulations have been developed, with the accompanying challenges and controversies, for example, in relation to nuclear energy. There are other unresolved problems, such as the storage of renewable energies, obtaining energy from what years ago was waste, such as poultry manure or brine from seawater desalination, among many other initiatives that favour the circular economy. Progress has also been made in the production of biopropane, decarbonization in the tertiary sector, in the hotel and catering industry, and in transport.

Thus, although the promotion of renewable energy sources is presented as the key to the energy transition, some of the social problems, such as growing energy poverty in the EU, will probably increase, for example, with the current war in Ukraine.

Finally, the information obtained will make it possible to detect the concepts identified, in order to train citizens in eco-social literacy.

Steps to Achieve Zero Emissions in the World and the EU Response

The leaders of the Group of Seven (G7)—that is the leaders of the world's most industrialized democracies (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States and a representative from the EU)—for the first time in history have aligned their goals in the fight against climate change and adopted concrete measures to accelerate the transition to clean energy sources. Specifically, they have reached the following agreements: to end direct government aid to thermal power plants that have not adopted anti-pollution measures, as this is the largest source of greenhouse gas emissions in the world; to provide $2 billion to support the work of the so-called Climate Investment Funds, which help developing countries transition to clean energy by providing funds for technology, training and infrastructure; and to launch an Industrial Decarbonization Agenda to speed up innovation, the use of technologies and the harmonization of standards to convert cement and steel production into clean energy sectors (Diario de León, 13/06/2021).

In 2019, the EU adopted a classification system, known as a taxonomy, to determine what is considered sustainable (Díaz 2020). This is a cross-cutting standard for all current and future European sustainable finance regulations. This common European classification of environmentally sustainable economic activities should, in turn, make it possible to determine the degree of sustainability of an investment. Achieving the SDGs in the EU requires channelling capital flows towards sustainable investments. The Taxonomy Regulation was published in the Official Journal of the European Union on 22 June 2020 and entered into force on 12 July 2020—Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance). The Taxonomy Regulation establishes six environmental objectives (Art. 9):

- Climate change mitigation
- Climate change adaptation
- The sustainable use and protection of water and marine resources
- The transition to a circular economy
- Pollution prevention and control
- The protection and restoration of biodiversity and ecosystems

At the same time, the European Green Pact has been established, which is a roadmap proposing zero greenhouse gas emissions by 2050 through the use of clean energy (La Rioja, Suplemento Agro 06/10/2020). This contains an action plan with 50 measures, which sought to reach 20% of energy consumption from renewables by 2020, but has achieved 22%. The quota is based on the initial situation of each country, with the Nordic countries starting from a higher level of renewable energy consumption (Sweden, with 49%, has reached 60% and Finland has reached 43.8%). On the other hand, France has fallen far short of this: although if energy from nuclear power plants is considered as green energy, it would reach the figure that corresponds to it (Planeles and Abril 2022). As an intermediate step, CO_2 emissions should be reduced to 40% by 2030 (Diari de Tarragona, 27/01/2022).

One of the energy sources that produces most greenhouse gas emissions is coal, which in the EU accounts for 15% of electricity generation (La Provincia Diario de Las Palmas, EFE, 03/02/2022). Hence, the decarbonization or progressive abandonment of fossil fuels and their substitution by clean energies is one of the main objectives of the energy transition. This energy transition should be based not only on environmental, technological, investment and employment efforts in clean energy, but also on policies and regulations (IRENA 2022). In relation to the latter, a report by the European Court of Auditors states that subsidies for energy produced by fossil fuels represent an obstacle to climate objectives, because they are slowing the energy transition; in fact, there are 15 EU countries that spend more on these subsidies than on clean energy (Esteller 2022).

In the same vein, the EU is collaborating with the "Race to Zero" global campaign launched in June 2020, which was designed for coalitions of companies, cities, regions and investors involved in net zero carbon initiatives, and affects over 20 economic sectors (UN 2021). In fact, the EU is leading the investment drive in areas such as renewables, heat pumps, electric vehicles, green hydrogen and carbon capture systems (Cepeda 2021). In addition, the European Commission has proposed 10 new European partnerships with the EU and will provide almost 10 billion euros, to which the Member States will have to respond with an equivalent investment. Industry will also participate. This proposal has a double objective: to accelerate the transition to a green, climate-neutral and digital Europe, and to make European industry more resilient and competitive. This is intended to have a positive impact on employment, the environment and society in the long term. This proposal also aims to institutionalize European partnerships to improve the EU's preparedness and response to infectious diseases, develop low-emission aircraft for clean aviation, support the use of renewable bio-based raw materials for energy generation, ensure European leadership in digital technologies and infrastructure and make rail transport more competitive (ESTRATEGIA EMPRESARIAL 01/04/2021).

The Nuclear Energy Issues

The Spanish press regularly refers to the EU's historic energy transition and decarbonization through the renunciation of fossil fuels. Specifically, for Professor Rallo (2022), the problem is that current living standards depend on the availability of cheap energy sources, such that suddenly doing without them could condemn citizens to unimaginable impoverishment. The cost of achieving net zero emissions, according to a Nature study, would be over $10,000 per person per year.

Although the EU is aware that neither gas nor nuclear are climate-neutral or renewable energies, it defends their role as "transition activities" to achieve its goal of a decarbonized economy by 2050 (Diario de la Rioja, Reuters, 03/02/2022) without excessive cost. The Commission insists that nuclear power projects can be considered green if they have received permits before 2045 and are in a country that has a plan—and funds—to safely dispose of radioactive waste by 2050. As for gas, plants that emit less than 270 g of CO per kWh until 2031 or less than 100 g over their entire lifetime (Rodriguez 2022) will be eligible for the green label.

Any decision must be based on scientific evidence at all levels, mainly environmental and socio-economic, in order to minimize negative consequences. Thus, experiments such as those carried out to shorten the life of radioactive waste, for example, the transmutation or bombardment of waste with protons, may be influencing some of these decisions.

Table 3 lists some of the main reflections in the press. It also reflects the unresolved problem of nuclear waste, which experts such as Inés Gallego says is small, as she argues that it is perfectly stored and controlled, both in Spain and in the rest of the world (Rodríguez 2022; Navarro 2022).

Nonetheless the controversy relating to nuclear power plants continues, with countries adopting a variety of positions: Germany has begun to close three nuclear power plants (BBC 31/12/2021) and is maintaining another three; the UK has 16 and will build six more in the coming years; France has 80—although according to

Table 3 Food for thought on nuclear: yes or not?

Subject	Data	Source
Safety	Safety levels start from the design of the installation to the operating procedures and the training of operating personnel	El Economista (07/01/2022)
Deaths	Nuclear power plants: 0.07 deaths per terawatt-hour (including the Chernobyl disaster resulting from mismanagement, and Fukushima resulting from a tsunami) Wind: 0.04 deaths per terawatt-hour Natural gas: 2.8 deaths per terawatt-hour Coal: 24.6 deaths per terawatt-hour	La Razón (3/01/2022)
Accidents	The probability of a catastrophic accident in a nuclear power plant is in the order of 1 in 1,000,000,000 per year of operation; much lower than the risk in aviation	WASH-1250 Report, El Economista (07/01/2022)
Cleanliness		
Emissions CO2	Regarding CO_2 emissions into the atmosphere: Nuclear power plants: 3 tonnes per gigawatt-hour Wind: 4 tonnes per gigawatt-hour Solar: 5 tonnes per gigawatt-hour Natural gas: 490 tonnes per gigawatt-hour Coal: 820 tonnes per gigawatt-hour	La Razón (3/01/2022)
Waste	Difficulty of management. One plant generates 27 tonnes in a year and a half (Fernando M. Legarda, professor of Nuclear Engineering at the UPV/EHU). Renewable energies also generate waste, for example, windmill blades are chopped up and buried	El Correo (08/01/2022)
Price (average cost)	Wind and solar energy: between 32 and 49 euros MW/h Solar energy has decreased in price by 85% and wind energy by 50% in the last decade Nuclear power: between 61–148 euros MW/h Nuclear energy has experienced an increase in costs	Fernando Valladares and Eloy Sanz, published in the journal Climática Noticias de Gipuzkoa (12/01/2022)

Source Press articles

other sources there are 58 active nuclear reactors (El Periódico 17/01/2022)—which produce 70% of the energy consumed, and at a better price for electricity than in other countries. Outside the EU, China's energy policy stands out, as it has 16 power plants that will be increased in number in the near future (Triper 2022). Nuclear power plants account for 27% of the energy consumed in the EU (De Miguel 2022).

Nuclear energy is supported by France, the Czech Republic, Hungary and Finland, while Germany rejects nuclear energy but is in favour of gas in the transition towards decarbonization (El Segre 09/02/2022). Thus, there are different positions on nuclear power as a clean and green energy. Spain, Ireland, Denmark, the Netherlands, Austria and Luxembourg have expressed their disagreement (Lucio 2022). Some argue that the proposal is intended to provide the nuclear industry with funding that it would not otherwise receive (Rekondo 2022).

On the other hand, the gas crisis in Europe is likely to accelerate the transition to clean energy and the adoption of green hydrogen as a viable alternative to gas and oil, according to the International Renewable Energy Agency (IRENA). The development of green hydrogen, made from water and using renewable electricity, has become a political priority with the aim of achieving emission neutrality by 2050 (Hook 2022). In fact, Siemens Group is already working on hydrogen systems for railways (HOY, Diario de Extremadura, 30/10/2020; Ideal 29/10/2020). It is expected that the International Energy Agency forecasts on the global capacity of electrolysers to produce hydrogen from water will be met, rising from the current 0.2 GW to 3300 GW in 2070, which would represent double the electricity generated today by the whole of China (González 2020). In Spain, the hydrogen energy revolution is being pushed by a large number of companies: Iberdrola, Endesa, Naturgy, Repsol, Cepsa, Enagás, Red Eléctrica, Acciona and Redexis, among many others (Expansión, Patiño, 08/01/2022). The Independent newspaper (15/02/2022) states that Arcelor, Enagás, Fertiberia and DH2 will create the largest renewable hydrogen hub in the world through the HyDeal initiative.

The EU is still 70% dependent on fossil fuels (coal, oil and gas), most of which are imported, such as natural gas from Russia, Norway, Algeria and Qatar. Therefore, increasing local production of solar and wind energy as well as energy storage is essential in the EU. In this context, the EU Energy Commissioner Kadri Simson has said: "We face rising energy prices, not because of climate policy or because renewables are expensive, but because fossil fuel prices are rising when we still don't have enough green and affordable energy for all. We need to accelerate the green transition, not slow it down". However, the fact that the energy crisis and the energy transition have focused on the supply side (i.e. on energy sources, rather than on the demand side by promoting smart, energy-efficient systems), has prevented users from adjusting to fluctuating supply prices, making it difficult to stabilize demand and reduce bills for businesses and households. Coordination of clean energy supply and storage would avoid weather dependence on wind and solar, which is essential in phasing out fossil fuels. Short-term needs can be met by batteries, but storage for long-term needs is still unresolved. In this respect, natural gas or reversible hydropower plants represent possible solutions (Boscardin Ching 2021).

Ongoing Initiatives

Renewable Energy Storage: Lithium Batteries

Rechargeable lithium-ion battery production is key to building a green energy workforce. The batteries enable solar and wind energy to be stored, making it possible to use when the sun goes down and the wind stops blowing. Thus, a European Battery Alliance was established in 2017, which has established sweeping goals for manufacturing, charging infrastructure and electric-car uptake. Europe will have 17 gigafactories by 2030. Europe is also pursuing development of its own lithium mines, to reduce its reliance on imports. And last month, the European Commission said it would spend $3.5 billion to subsidize Tesla, BMW and other companies to produce more batteries in Europe and help cut imports from China (Jeanne Whalen, Washington Post 11/02/2022). In this line, we can cite the Swedish company Northvolt, Europe's leading electric battery company. (Expansión, 12/01/2022; Financial Times).

The Use of Manure from Poultry Farms

The Avienergy project, financed with nearly 600,000 euros from the European Fund for Rural Development (EAFRD) and the Spanish Ministry of Agriculture, Fisheries and Food, promotes the use of the millions of tonnes per year of droppings generated on poultry farms to obtain renewable energy and fertilizers. It is coordinated by Feuga (Fundación Empresa Universidad Gallega) and involves the University of Vigo, the Centro de Edafología y Biología Aplicada del Segura (Cebas-CSIC) and several companies from the Autonomous Communities of Galicia, Castilla y León and Murcia (Narón Demaux Manufacture S.L., Granja José Antonio García Blanco, Avícola El Charcón S.L. and Alimentos del Mediterráneo Sociedad Cooperativa…). The Vigo-based technology centre EnergyLab, a partner in the initiative, is creating small-scale plants on the farms themselves to recover the manure from chicken and turkey-fattening farms, known respectively as pollinaza and pavinaza, and reduce energy dependence on the poultry facility itself. In this way, this initiative differs from others, such as Spain's Coren, which combusts poultry manure with wood pellets, and others from abroad (the UK, Netherlands and USA). The generation of thermal energy is produced in the same way as the burning of a wood pellet, and it is possible to do so with a poultry manure pellet, once it has been dried or mixed with other forest biomass from the area as residual wood. At the conclusion of this preliminary phase at the Ourense farm, combustion tests will be carried out on the biomass produced for the generation of hot air and the conditioning of the warehouses by the Energy Technology Group (GTE) of the University of Vigo, which studies the thermal behaviour of the waste from a physicochemical perspective (i.e. the drying techniques and the different regulations applicable to the combustion of this type of waste). It is also collaborating in the design of a burner adapted to poultry droppings, as well as in the definition and implementation of flue gas cleaning systems. After the analysis of emissions from the process, the need to implement additional flue gas cleaning systems for regulatory compliance will be assessed. Experts will evaluate the toxicity of the ashes produced by the combustion process of poultry and chicken manure, and their potential use in soils and will develop the agricultural protocol for their use—since the legislation in Spain establishes a maximum of tonnes of nitrogen present in manure per hectare of agricultural land, which forces its storage in areas of high livestock load, generating diffuse emissions—and manage it externally, with the cost that this entails. Furthermore, if this management is not carried out correctly, problems of aquifer contamination, ammonia dispersion and bad odours may arise (Faro de Vigo 21/09/2021).

Along the same lines, but in this case from the use of pig slurry, a fertilizer with high value or biomethane (bio-CNG) is obtained for use as fuel in vehicles or in the heating boilers of municipal facilities, although it can also be distributed through the natural gas network. Thus, the Advisor project has succeeded in transforming livestock waste into methane biofuel for vehicles that can be refuelled in a 'biogas station' at the Guijelo sewage treatment plant. There are currently nine such vehicle refuelling stations in Spain, six of which have been developed by Aqualia (Chiclana de la Frontera, Jerez, Almería, Lérida, Guijuelo and Granada) (González 2021).

Energy from Brine from Seawater Desalination

Sacyr Agua and the Life Hyreward project obtain clean and renewable energy through a combination of reverse osmosis and reverse electrodialysis or RED (Reverse Electrodialysis) from brine from water desalination. In this way, up to 20% of the energy used in the reverse osmosis process of seawater is recovered by using the osmotic gradient between the high-salinity feed stream and the wastewater treated as a low-salinity stream to generate electricity (El Economista 04/01/2022).

The Production of Biopropane, or Renewable Propane

This is based on the fact that it is chemically identical to conventional propane, so that a complete switch from one product to the other does not require any adjustments to existing installations, and it is also possible to mix the two products. Biopropane is produced from a mixture of food industry waste and vegetable oils with a lower environmental impact (emission reductions can be up to 80%), as it is completely organic in origin. It is the only propane gas that complies with the European Renewable Energy Directive (RED). As it is liquefied at high pressure, it is easy to store and transport, making it accessible in rural areas not connected to the natural gas network. In this way, the energy transition is global and inclusive, as it can also contribute to the progress and development of rural areas (El Economista 15/06/2021).

Decarbonization in the Tertiary Sector: Hotels and Transport

Meliá hotels—which use renewable energy sources in 100% of their hotel facilities in Spain, France, Italy, Germany and the United Kingdom—are the most sustainable hotel company in Spain and Europe and the second in the world behind Hilton, according to S&P Global (Expansión 02/02/2022).

In air transport, Iberia is partnering with Cepsa to promote renewable energy (El País 25/01/2022). In rail transport, we can highlight the FCH2RAIL proposal selected by the European Commission's agency dedicated to promoting the development of hydrogen and fuel cells, which is technically led by the Basque group CAF, for the development of a hydrogen-powered train prototype. This involves Spanish, Belgian, German and Portuguese companies (CAF, DLR, Renfe, Toyota Motor Europe, Adif, IP, CNH2 and Faiveley Stemmann Technik). The project is expected to last around four years and has a budget of more than 14 million euros, of which around 70% will come from European funds. The prototype will be based on a three-car Renfe commuter train (Cao 2020). Mobility of the future is based on four trends: electrified, shared, connected and autonomous (El Economista 30/10/2020).

Amazon is preparing to power its logistics network in Spain with solar energy, which is expected to provide 302,000 MWh of clean energy per year, the equivalent of the average consumption of 30,000 homes, in Seville and Zaragoza, complemented by wind energy in six facilities to be set up in Europe, starting with Sweden and Ireland (El Economista 19/11/2020 and 11/12/2020).

In the field of micromobility, the solar pavement of the company Solum consists of a conventional module that is a photovoltaic panel to which a series of materials are added that are capable of transforming the module into pavement, which is what provides clean energy for micromobility (scooters, bicycles and mopeds) without aesthetically affecting the urban environment and constituting an autonomous charging station that is not dependent on the electricity grid. Supported by several companies (Telefónica, Capital Energy, Naturgy and Iberdrola), they have installed projects in Seville, Valencia and Madrid. They also plan to set up projects in other Spanish cities, such as Barcelona, (now underway), Malaga, Valencia, Bilbao… and in Holland, France and Italy (EMPRENDEDORES 26/11/2021).

Promoting Renewable Energy Sources

Renewable energies are resources that do not run out in nature, do not pollute and are environmentally friendly. In terms of their origin or source, they are wind, solar, biomass, hydro, geothermal and tidal energy. The media are currently focused on those that have seen the greatest development in recent years, which are mainly wind and solar energy. There is also mention of offshore wind with different anchoring systems for floating wind turbines, on which Basque engineering companies such as Saitec are working, and the Flow offshore wind project, among many others (Legasa 2022).

Renewable energy sale and purchase contracts, mostly linked to photovoltaic energy, are very active in 2019, accounting for 2.6 GW in Europe (Díaz 2020). Ibiza has multiplied the number of photovoltaic installations tenfold in three years (Última hora 26/01/2022).

Renewable parks generate a large number of jobs during their construction, but not for their maintenance (El Periódico, 11/01/2022). 'Self-created renewable energy resources' also appear to be growing with initiatives such as the installation of solar panels on state schools (Información 21/01/2021) or on the roofs of people's own houses.

Thus, energy dependence seems to be shifting its centre of gravity from dependence on fossil fuels to metals such as lithium or copper, rare earth elements, batteries, electrolyzers to produce hydrogen, wind turbines or solar panels. All of these have components that are not homogeneously distributed, which will continue to lead to geopolitical problems (Bermúdez 2022).

The Other Side of the Coin: Energy Poverty

Energy prices in the UK, Europe and Asia have hit record highs in recent weeks triggering inflation concerns (Josephs 2021). Thus, energy poverty is emerging and initiatives such as the Alliance for Electrification, formed by some of the main associations related to energy in Europe (AVERE-the European Association for Electromobility, European Heat Pump Association, Eurelectric, European Climate Foundation, European Copper Institute, EuropeOn, The European Association of Electrical Contractors, Renewables Grid Initiative, smartEnsmart Energy Europe, SolarPower Europe and WindEurope), have sent a letter to both, the Vice-President of the European Commission, Frans Timmermans, and to the Commissioner for Energy, Kadri Simson, to directly support the most vulnerable households, especially those suffering from energy poverty. In this case, on a temporary and limited basis, the EU is allowing price intervention, with the possibility of structurally reducing taxes and levies on electricity bills and fully implementing the provisions of the Clean Energy Package to guarantee flexible consumption for all. These associations claim that electricity price rises have led national policy makers to react on a whim and intervene in the functioning of the market. This response to short-term price volatility undermines the EU emissions trading system, distorts the internal electricity market and derails the energy transition (El Economista 23/09/2021 Rubén Esteller).

EU legislation related to the electricity market is not being fully implemented in Spain, especially in the area of demand flexibility, which excludes the benefits of adapting consumption to these fluctuations.

This situation has prompted EU employers to call for an accelerated transition to clean energy to protect against fossil fuel price volatility. The EU Green Deal and the ambition of climate neutrality clearly point in this direction.

Eco-social Literacy: The Main Concepts for a Clean Energy Future

As previously mentioned, there are important concepts related to clean energy that all citizens should know. Some of these concepts come from media learning resources, while others are from information in the media itself.

The BBC Learning English web page offers key language terms related to energy (https://www.bbc.co.uk/learningenglish/english/features/lingohack/ep-211124) and highlights words such as renewable, clean fuel, plant, grid and fossil fuel, defining them as follows:

> renewable—something that does not degrade and can be used again and again.
> clean fuel—energy used for heat and power which is made using renewable sources.
>
> plant—a factory that produces energy or a particular product.
>
> grid—a system of wires and cables through which electricity is distributed.
>
> fossil fuel—organic matter which is burnt for energy

At the end of their list, the BBC adds a key question: what is used to produce green hydrogen?—in order to also introduce the idea of green hydrogen technologies.

However, this list of concepts is insufficient, as has been seen in the text. There are other concepts that are also important, such as renewable energies, clean energy, energy poverty, biopropane, circular economy, decarbonization and, of course, the units used for energy measures. In addition, there is a catalogue of colours related to the electricity's origin: green, if it is generated with renewables; blue, if it is generated with gas; and grey, if it is generated with hydrocarbons.

Conclusions

The method of using the press to bring citizens closer to the discourse generated in the media in relation to the energy transition and to identify the concepts used in it has been useful, as it contains different explanations of these concepts. The energy transition needs all citizens collaboration and it is important to know all details about it, and a better understanding of different countries and politicians positions that the press is explaining.

After the data collection, we can affirm that the EU is ahead of the intermediate target figures agreed in the European Green Pact and well ahead of other countries in the world, on which it depends energetically, although it remains to be seen whether it will be possible to reach zero emissions by 2050.

This energy transition, which can be described as accelerated in the EU, is based not only on the desire to curb climate change by reducing greenhouse gas emissions, which accounted for more than 75% of emissions (European Green Deal 2022), but also on the need to protect against the volatility of fossil fuel prices.

It can easily be seen that energy generated by renewables is now competitive in the EU with all other forms of conventional generation. “If you push clean energy, energy efficiency, solar electric cars and other solutions, you don’t need to use fossil fuels anymore, you simply switch to clean energy sources” (https://www.bbc.com/news/business-58901566).

However, many challenges remain in relation to technology, such as energy storage; and in governance, for example, improving efficiency and savings in demand and in the investments necessary for a satisfactory European energy transformation. It is still unclear, however, if the socio-economic effort made will be sufficient. We agree with Martín-Roda (2021) that it seems difficult, for the time being, to be able to produce all the energy demanded from clean and renewable energies, due to the mismatch between production periods and effective electricity demand. This leaves open the debate as to whether nuclear energy and gas will be necessary in the European energy transition, to which the armed conflict in Ukraine adds uncertainty.

Acknowledgements This chapter was undertaken within the project: “*La alfabetización ecosocial: un elemento central en los procesos de sostenibilización curricular para el logro de la Agenda 2030 (ODS) en la formación inicial del profesorado*” (PRAD-ODS) (RTI2018-095746-B-I00) (I+D+i proyectos “Retos investigación”), funded by the Ministry of Science, Innovation and Universities, and led by Dr. María Ángeles Murga-Menoyo.

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SDG 8. Promote Sustained, Inclusive, and Sustainable Economic Growth, Full and Productive Employment, and Decent Work for All

“Economics for Future” from Different Perspectives—Critical Reflections on SDG 8 with a Special Focus on Economic Growth and Some Suggestions for Alternatives Pathways

Andreas Eberth, Christiane Meyer, and Lydia Heilen

Abstract This chapter scrutinizes the UN’s commitment to economic growth as described in SDG 8 whilst providing a critique of its neoliberal understanding of development. It presents various alternatives for “economics for future” from post-growth economies whilst considering different scales and perspectives. The young are considered central to the implementation of 2030 Agenda for Sustainable Development. Selected findings from an empirical survey of young people’s views from Germany are therefore presented and discussed in relation to post-growth economies and sustainability. The findings suggest that, whilst the younger generation is interested in concepts of diverse economies, it has little knowledge about them. Some recommendations are provided for further research and for integrating these ideas into the subject of geography in secondary and higher education.

Keywords SDG 8 · Economic growth · (Post-)Neoliberalism · Post-growth economies · Sustainability · Young people’s perspectives

Introduction

The overarching aspiration of SDG 8 is to “[p]romote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all” (UN 2015, 14). The explicit goal of maintaining economic growth pervades the entire agenda. Target 8.1 sets the goal of sustaining “capita economic growth in accordance with national circumstances” (ibid., 19). Target 8.4 specifically calls for

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_8

economic growth to be decoupled from environmental degradation by improving "global resource efficiency in consumption and production […] with developed countries taking the lead" (ibid). The aim is to balance "higher levels of economic productivity" (Target 8.2, ibid.) within the boundaries of available resources although it remains unclear how the twin goals of growth and a healthy environment will be achieved. SDG 8 attempts to incorporate the current status quo and current economic paradigms (i.e. at least 7% annual GDP growth in the least developed countries) into a more sustainable frame without stating clear new visions and economic models. The agenda focusses on the tourism sector as a global growth market (Target 8.9, ibid., 20) without critically reflecting on issues of over-tourism at some destinations (e.g. the European cities of Barcelona, Dubrovnik and Venice; Pechlaner et al. 2019). Targets 8.3 and 8.a express a clear orientation towards the development paradigm without discussing the issue of development itself (UN 2015, 19–20).

The discrepancy between economic growth and sustainability is ignored by SDG 8 and needs to be confronted.

This chapter scrutinizes SDG 8 in relation to neoliberalism and the economic growth paradigm and makes some suggestions for post-growth economies as economies of the future from different scales and perspectives. These considerations are supplemented by selected views from young Germans on post-growth and sustainability. As young people are seen as playing a crucial role in the implementation of the 2030 Agenda, some implications are derived for further research and geographical education.

Critical Reflections on SDG 8

SDG 8 pursues an agenda reflecting economic growth and development paradigms which is at odds with current geographical debates (e.g. Harvey 2020; Lange et al. 2021; Ziai 2015). "Geographers, sociologists and anthropologists have been active in critiquing neoliberal models as well as documenting the work done by neoliberal discourse and the cultivation of new practises and meanings associated with development" (Wolford 2016, 583). A Western understanding of development and the goals that need to be pursued in order to achieve this state have been imposed on countries of the Global South. A debate exists as to whether the term "underdevelopment" was invented in order to facilitate the spread of capitalism and neoliberal structures across the globe (Escobar 2012, 3f.; 55ff.). Despite seeking to initiate a change in thinking, the continuing application of the term "developing countries" means that SDG 8 fails to break with the underlying assumptions of the development paradigm.

From a geographical perspective, the following aspects listed in the SDGs are particularly relevant: The focus on economic growth in SDG 8 reveals a Western capitalist development paradigm linked to prosperity. It is necessary to present a range of critiques of the growth paradigm, which is closely related to the influence of neoliberalism. "First and foremost in this deliberation on sustainable development's ambiguous nature is the mismatch between the power and consequential political economic authority of neoliberal capitalism's free-market messages and the eco-development messages that sustainable development promotes" (Potter et al. 2012, 103). This perspective is supported by Maja Göpel who views "[…] the most critical aspect for turning the wheel towards fulfilling the SDGs is changing the economic paradigm" (2016, 3).

An orientation towards neoliberalism has shaped the economic system since the second half of the twentieth century, replacing post-war Keynesian models and promoting privatized and competitive free markets (Potter et al. 2012, 82; Tickell and Peck 2003). "Both globalization and neoliberalism have risen to prominence in about the same period and are associated with changes to the state and the market, and the shift to internationalized, export-oriented economies, and a laissez-faire capitalism that depends on deregulation" (Gilbert 2016, 300). This has been accompanied by increasing socio-economic inequalities and divisions on local and global scales (Dicken 2015, 381). "Neoliberal capitalism's particular feat since its emergence in the 1980s has been to increase social divisions, widen the economic gap between the very rich and the very poor, and centralize authority for the management of corporate and financial capital" (Potter et al. 2012, 85). David Harvey lists four driving elements that ensure power resides with capitalist elites worldwide. These are privatization, financialization, the management and manipulation of crises as well as state redistributions (Harvey 2019, 44ff.) The process of what he refers to as "accumulation by dispossession" rose to prominence quickly and continues to this day (2019, 41; 2020, 121ff.) and there is no clear end to neoliberalism despite the massive impact of the global financial crisis in 2007–08. It is seen as a logical manifestation of globalized capitalism rather than an aberration (Hilary 2013, 138). Even though the underlying economic system has not changed, neoliberalism has forfeited much of its political legitimacy. People are more discontent and feel alienated by the economic system (Harvey 2020, 18f.). However, it is apparent that, even if acceptance has waned, a global crisis is not the decisive factor for overcoming neoliberal capitalism. "Capitalism will continue to lurch from crisis to crisis as a result of its own internal contradictions, creating the objective conditions for its eventual demise and replacement by systems that are not predicated upon the continuing immiseration of classes, peoples and communities or the destruction of the planet on which we live" (Hilary 2013, 160). Capitalism will therefore destroy itself and, due to its destructive nature, it is also at odds with the goals of climate protection (Klein 2014). While climate protection aims to preserve the environment, neoliberal capitalism strives for short-term profitability and maximum benefits from unregulated resource exploitation, wasteful production and market-driven objectives (Potter et al. 2012, 103). As the aims of climate protection and neoliberalism are at odds to each other, sustainable development is not possible under the current economic regime. The short-term focus of neoliberalism contradicts the long-term ecological focus of sustainability and the objective of people-centred development in relation to the preservation and conservation of the earth's biomass resources (ibid.).

Closely intertwined with neoliberal capitalism is the notion that steady economic growth is needed to enable and secure prosperity. Economic growth can be understood as "a sustained increase in the production of goods and services, usually measured at the national level as the change in the gross domestic product (GDP) of a country's economy" (Peck 2009, 181). However, the fact that growth can also exacerbate social inequality is often overlooked (Harvey 2020, 99f.). In addition to social inequality, the devastating consequences on the environment and the intensification of climate change also need to be taken into consideration (ibid., 104; 144). "The endless and compounding growth syndrome of contemporary consumerism which parallels the endless accumulation of capital needs critical evaluation and response. We should, for example, be thinking more creatively of decreasing and controlling the mass of resources we are extracting from the bowls of the earth to feed the contemporary compensatory consumerism that is so critical to the endless accumulation of capital" (ibid., 111). The recognition that social and environmental growth is limited is gaining widespread acceptance (Peck 2009, 182). The current way of doing business is not compatible with ideas of sustainability, thus, sustainability and growth are mutually exclusive (Daly 2010). "Sustainable development as global objective is replete with ambiguities because it has to reconcile two very different growth trajectories, short-term hard growth and long-term environmental sustainability. Neoliberalism's persistence as a dominant global economic faith prevents environmental sustainability from being pursued" (Potter et al. 2012, 108). Tim Jackson concludes that the "myth of growth has failed us. […] It has failed the fragile ecological systems on which we depend for survival" (Jackson 2009, 15). He questions the growth paradigm and advocates a system change for post-capitalist era (Jackson 2021). In order to achieve this, different economic values are required to replace neoliberal capitalism with a fairer social, economic, environmental, political and cultural system (Harvey 2019, 68). Initial attempts to find alternative business models that consider these values are being made. These experimental spaces are emerging parallel to neoliberal economic system (Peck 2009, 182). SDG 8 mirrors the continuing antagonism between growth and environmental protection. Instead of promoting a new way of thinking about the economy, it merely incorporates a green economy within the current neoliberal framework, and thus represents a missed opportunity (Target 8.4). It is time to look beyond neoliberalism towards an economic system oriented on democratic commitment to the common good and climate protection rather than profit (Elwood et al. 2017, 692). Table 1 provides an overview of some selected characteristics of the mainstream economy and the orientation of alternative economies (referred to here as the community economy).

Going Beyond: Designing the Post-growth Era

"If the main achievements of neoliberalism have been redistributive rather than generative, then ways had to be found to transfer assets and redistribute wealth and income either from the mass of the population towards the upper classes or from vulnerable to richer countries" (Harvey 2019, 43). The guiding principles of 2030 Agenda are defined as "the five p's": people, planet, prosperity, peace and partnership (UN 2015). It is important to consider how other ideas promoted by SDG 8, such as "prosperity

Table 1 Contrasting characteristics of mainstream and community economies

Mainstream economy	Community economy
Aspatial/global	Place-attached
Specialized	Diversified
Singular	Multiple
Large scale	Small scale
Competitive	Cooperative
Centred	Decentred
Acultural	Culturally distinctive
Socially disembedded	Socially embedded
Non-local ownership	Local ownership
Agglomerative	Dispersed
Integrated	Autonomous
Export-oriented	Oriented to local market
Privileges short-term return	Values long-term investment
Growth oriented	Vitality oriented
Outflow of extracted value	Recirculates value locally
Privately owned	Community owned
Management led	Community led
Controlled by private board	Community controlled
Private appropriation and distribution of surplus	Communal appropriation and distribution of surplus
Environmentally unsustainable	Environmentally sustainable
Fragmented	Whole
Amoral	Ethical
Crisis-ridden	Harmonious
Participates in a spatial division of labour	Locally self-reliant

Dicken (2015, 382), based on Gibson-Graham (2006, Fig. 23)

without growth", can be realized (Jackson 2009). Answers can be found in various alternative pathways discussed using the terms *degrowth* and *post-growth.*

> Post-growth is not synonymous with shrinkage (e.g. of the population) or recession (e.g. of economic output). Rather, it is about abandoning the illusory notion that technological innovations and improved efficiency can ensure the long-term global growth of current production systems and consumption patterns, thereby improving living conditions for all. […] In essence, it is about adjusting understandings of growth and re-evaluating it, examining the long-term meaningfulness of certain developments and, if necessary, looking for possible alternatives within free social conditions. Meaningfulness refers here not only to the environment but also to individual and social needs, i.e. a focus on the common good rather than individual economic profitability (Schulz et al. 2021, 20).

A stronger orientation towards *degrowth* and *post-growth* would be a desirable aim for societies of the Global North (Lange et al. 2021). Postcolonial and indigenous perspectives should also be considered (Dengler and Seebacher 2019; McGregor 2004; Struckmann 2018) to counterbalance the destructive forces of accumulation by dispossession and land grab as well as dumping wages and bank bailouts with taxpayer's money (Santos 2015). Placing the common good and common resources under the laws of capitalism results in the displacement of indigenous communities and low-income farming while exacerbating ecological crisis, colonialism and racism and the desire for appropriation and various forms of violence perpetrated against those considered inferior (Santos 2015, 74). Regionally differentiated solutions (see Target 8.1) and a differently accentuated interpretation of SDG 8 is necessary. There is a discussion that some countries require a temporary phase of adequate economic growth. "Degrowth places a strong emphasis on the issue of distributive justice in growth and wealth, both at the level of international and development policies and within individual national economies […]. Degrowth is thus more than a simple "ecological limits" or erstwhile "limits to growth" debate; rather, it represents a re-framing of the very definition of economic prosperity towards enhancing well-being and human happiness" (Krueger et al. 2018, 578; see also Whitehead 2013). Escobar (2018, 140) emphasizes the geopolitical differences in the transformation discourses in the Global North and the Global South while noting important overlaps and commonalities in the critiques of capitalism and neoliberalism. "While the age to come is described in the North as being post-growth, postmaterialist, post-economic, post-capitalist and post-human, for the South it is expressed in terms of being post-development, non-liberal, post-capitalist/non-capitalist, biocentric and post-extractivist" (ibid.). A spatially differentiated approach towards the meaning and necessity of growth is required and alternative economic models, such as the Doughnut Economics according to Raworth (2017) or Niko Paech's Post-growth Economy (2012), the degrowth or post-growth movements (Lange et al. 2021; Escobar 2018, 137ff.), Utopias (e.g. Haraway 2016) as well as a multitude of local initiatives around the world that are being tried out (for an overview see e.g. Burkhart et al. 2020; Fig. 1). "The diversity of alternative economies is growing and offers significant possibilities for creating fulfilling and fair communities" (Dicken 2015, 382). Degrowth initiatives closely related to the idea of the commons are well known in the Global North (Bollier and Helfrich 2019; Bollier 2014; Thompson 2019). The Transition Town Movement (Hopkins and Heinberg 2008; Hopkins 2011), which has its origins in the United Kingdom, is being adapted by groups working creatively on transition pathways on a local scale in cities all over Europe. Macy and Johnstone (2012) provide general orientation with their remarks on "the Great Turning" which involves three dimensions, "holding actions", "life-sustaining systems and practises" and a "shift in consciousness". The second dimension can be brought about by pioneers of change. These change agents are "single individuals and small groups […]. They propagate innovations by questioning "business as usual" policies and creating alternative practises, thereby challenging the established world views and paths, attitudinal and behavioural patterns, as well as providing others who think

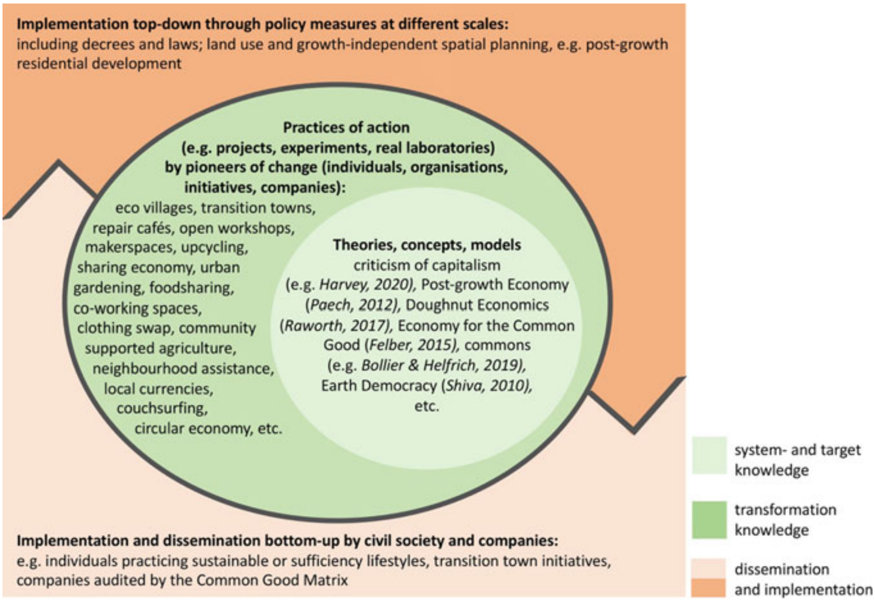

Fig. 1 Overview of different approaches in the field of post-growth economies (own illustration)

as they do (followers, early adopters) with a constant motivation for a self-sustaining change" (WBGU 2011, 243).

There are different transition initiatives in countries and communities in Africa, Asia and South America. In Kenya, for example, the Nobel Peace Prize laureate Wangari Maathai has contributed to strengthening women's rights and mitigating environmental degradation with dedicated initiatives in rural areas such as the Green Belt Movement (Maathai 2009). The careful adaptation of traditional land use systems is another progressive example (Oba 2013; Fratkin 2013). Community-based organizations and youth initiatives in the slums of the capital Nairobi and other urban centres contribute to community development and the common good (Sana 2016; Eberth 2021). These initiatives can be described as change agents for urban transformation (WBGU 2016, 313ff.). Vandana Shiva criticizes the Green Revolution in India (2010a) and demands more justice and environmental protection in times of globalization (2015). Shiva founded the Navdanya initiative to establish sustainable forms of agriculture. The concept of "Earth Democracy" presented in her work involves establishing more justice, sustainability and peace (2010b). In addition to critiques of the onto-epistemic field in the context of postcolonial contours, the concept of Buen Vivir in South America has become widespread (Escobar 2012, 2018; Mignolo 2011). This is understood as promoting the harmonious coexistence of different types of communities within the natural world (Acosta 2019; Roa 2018) rather than striving to attain a single, homogeneous notion of good life.

These ideas help to shape democratic, participatory, inclusive, pluriverse, sustainable societies (Escobar 2018). Three aspects provide guidance for alternative economies: popular sovereignty, common ownership and social production (Hilary 2013, 148ff.). Despite being all different in their design, all these ideas are similarly guided by the belief that "good life beyond growth" is possible (Rosa and Henning 2019).

When looking for alternatives to a capitalistic economy on a meta-level, a closer look at South America is helpful. Certain communities, societies and policies in South America have "led the way in developing real alternatives to the neoliberal capitalist model in the twenty-first century" (Hilary 2013, 139). Taking Bolivia and Venezuela as examples, Doreen Massey focuses on the three areas of democracy, media and space to which she attributes particular importance in connection with transformative potential. Massey argues that these post-neoliberal experiments in South America are "socio-political spaces that are democratic and more egalitarian" (Massey 2012, 136). Such initiatives have "the potential for long-term, structural change" (Hilary 2013, 139) and make it possible to develop "designs for transitions" (Escobar 2018, 137ff.). Established social movements in many societies of the Global South can provide role models for the Global North (Escobar 2018, 149). Global cooperation is also necessary to forge a common and diverse postcolonial future and establish new sense of global togetherness in addition to creative engagement in communities on a local level. Existing global power relations dominated by the West must be questioned and the influence of economic global players needs to be dismantled. The aim of creating a distance from the Eurocentric tradition is to create analytical spaces for realities that are surprising because they are new, have been previously ignored or made invisible, i.e. deemed non-existent by the Eurocentric tradition (Santos 2015, 73). This can be particularly promising if it is about new orientations and not just about forms of green washing. "On the degrowth side, a main risk is the subversion of its meaning through green-economy and post-growth schemes that leave untouched the basic architecture of economism" (Escobar 2018, 149). All the initiatives mentioned here make a significant contribution to the debate on a socio-ecological transformation. "These solutions are inherently relational, not comparative; they highlight the interconnectedness between people, places and politics around the world. It is not clear where exactly the energy from these movements will lead but there is no question that over the past thirty years, they have helped to highlight the conditions of economic injustice. In doing so, they have re-shaped the future of a political economic ideology that once seemed so hegemonic there could "be no alternative" (Wolford 2016, 584).

Young People's Perspectives on Post-growth Economies

It is necessary to investigate the perspectives of younger generations on 2030 Agenda and the SDGs as their involvement will central to achieving the transition away from the current economic paradigm towards a post-growth economy (UNESCO 2020).

Do young people support “system change, not climate change” as demanded by Fridays for Future, and which alternatives to the current neoliberal economic system are they aware of? To our knowledge perspectives on the problems of economic growth in relation to sustainable development and knowledge about alternative economic models have not yet been empirically surveyed for this age group. The present research project at the Leibniz University Hannover (Institute of Science Education, Geography Education Section) which runs from 2019 to 2022 and is funded by the Lower Saxony Ministry for Science and Culture aims to make up for this deficit.

Young people around Germany aged between 15 and 24 were asked to answer a standardized online questionnaire ($n = 150$; survey period: August to December 2020). Selected findings of the quantitative survey are presented here. The survey posed the following questions:

1. What are respondents’ views on various statements on the connection between economic growth, climate change and post-growth?
2. How do they emphasize the role of secondary education for knowledge about post-growth economies?
3. What kind of selected initiatives from the field of post-growth economies do the respondents know about?

The respondents for the online questionnaire were found through social media, mailing lists of special organizations like Fridays for Future and study courses and special survey portals. Of the 150 individuals questioned, 63.3% were female, 32.7% male and 2.7% non-binary. With a share of 91.2%, the sample was mainly aged 18–24 years. 65.6% of the respondents attended university. 9.4% attended school and were mainly studying for the general qualification for university entrance (Abitur), indicating a high level of education.

The respondents were asked about various aspects of sustainability referred to in the SDGs, including their views on post-growth economies. The part of the questionnaire on post-growth economies asked participants to evaluate statements on a five-tier Likert-Scale ranging from “I fully agree” to “I do not agree at all”. There were also several multiple-choice questions.

The results shown in Fig. 2 reveal that most of the respondents had not heard of post-growth (92.7%). 85.4% agreed that “system change, not climate change” was at least partially necessary. A majority blamed capitalism for the climate crisis (74.7%) and agreed that an alternative to economic growth was necessary in order to achieve sustainable development (82.7%). It is therefore possible to infer that, whilst the respondents think it is necessary to find alternatives to the current economic system, they lack knowledge of specific concepts. A clear desire that post-growth as a topic (83.3%) and specific post-growth initiatives (78%) should be addressed in secondary and higher education was also expressed. The neo-liberalization of markets and politics is reflected in the focus on economic growth in education (Mitchell 2018). A critical approach towards economic growth and an understanding of alternative economic systems needs to be promoted. Educators can introduce eco-centred world-views and successful projects in their lessons to help inform young people about alternative, non-human-centred economic systems. Geography as a subject taught at universities and schools should therefore cover this field more thoroughly and continue to develop existing approaches to post-growth geographies (Lange et al. 2021).

A second set of questions were designed to assess which post-growth initiatives are familiar to young people and the level of participation (see results in Fig. 3). A similar picture of knowledge of post-growth alternatives to that in the statements in Fig. 1 emerged. The respondents were predominantly aware of low-key initiatives that have become popular amongst students such as clothing swaps or urban gardening. However, initiatives that aim to tackle the economic system more fundamentally, e.g. transition town, were less well known. The respondents appeared neither to know very much about different ways of thinking the economy in a broader sense nor, more specifically, about current grass roots initiatives at a local level. It is also interesting to note that despite awareness of low-key initiatives, the actual level of participation was low. Apart from clothing swaps, participation in post-growth initiatives is low. Knowledge of alternative models to consumption seem not to have yet translated into action amongst the respondents. Further research would aim to provide insight into the factors hindering young people to get involved in post-growth initiatives more actively.

The findings above have been used to design a qualitative research project. We conducted focus groups in order to offer young people the opportunity to present their perspectives on post-growth economies more comprehensively. In contrast to an individual interview, focus groups allow participants to discuss opinions, attitudes and values without being overly influenced by the researcher.

We planned three meetings with each of the seven groups in order to investigate how engagement and transition initiatives at a local scale relate to perspectives at a global scale.

The first meeting was used to discuss the Fridays for Future slogan “system change, not climate change”. We also investigated the extent to which the respondents see the relationship between the economic system, politics and society. The respondents were therefore asked about their views on the growth-oriented economic system and invited to comments on the central theses of Tim Jackson, Naomi Klein, Niko Paech and Vandana Shiva. Each focus group then discussed the approach of post-growth economies and the importance of local initiatives as change agents. The participants then said which change agents they are familiar with in the Hannover region. The group then decided which initiative they would like to discover more about. The participants conducted an interview with the representative of the initiative they have chosen and the aspects of the initiative they show particular interested in have been noted.

In a third meeting, which is planned as a focus group again, the participants finally reconvened to reflect the insights they have gained from the interview and discussed the way in which post-growth economies and the role of change agents raised within the research project could be taught in a school environment.

After the survey phase has been completed, the results will be transcribed and evaluated. This study is still ongoing. At this time, we can notice that the insights

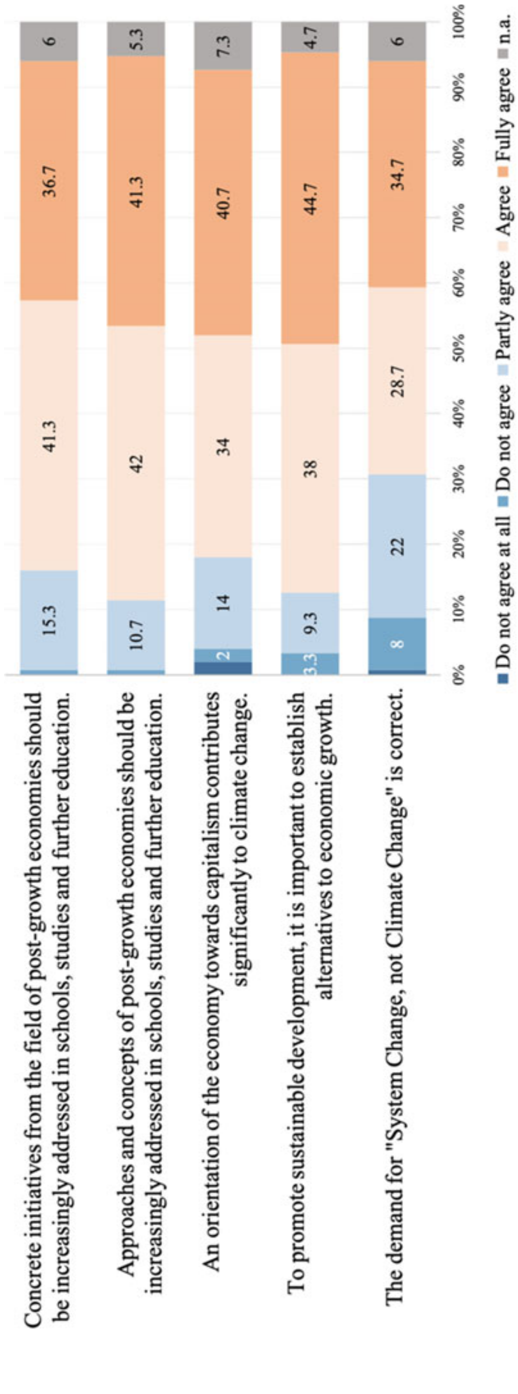

Fig. 2 Statements on post-growth economies, $N = 150$, answers above 1%

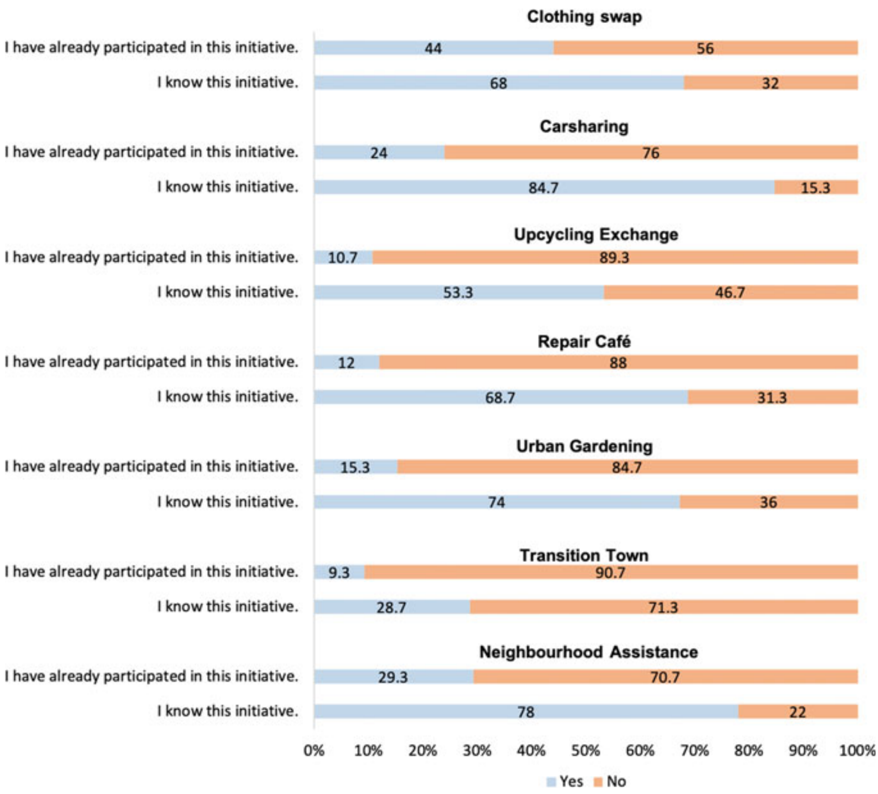

Fig. 3 Knowledge of and participation in different post-growth initiatives of young people, $N = 150$

are very interesting and meaningful to make young people's perspectives visible and derive implications for educational processes.

Conclusion

This chapter summarizes positions on SDG 8 from different critical perspectives: The economic growth paradigm (Tim Jackson, Kate Raworth), neoliberalism (Rob Potter, David Harvey) and the concept of development (Arturo Escobar, Aram Ziai). As the young are viewed as central to achieving the aims of the 2030 Agenda, we supplemented this summary with a quantitative survey of young people in the Hannover region of Germany. This revealed that young people are also critical of the capitalist economic model and are interested in exploring alternatives from the field of post-growth economies. UNESCO sees young people playing a decisive role in the implementation of the SDGs, even though the goals they pursue through SDG 8 seem to contradict this. Hence, the perspectives of young people are not represented.

We also discussed contrasting approaches towards degrowth and post-growth in the Global North and South, implemented at the local or regional level where change agents play a key role as initiators e.g. Vandana Shiva, Rob Hopkins and initiatives such as Navdanya and Transition Town. Our survey showed that the respondents were aware of some initiatives (at the local or regional level) and were keen to learn more about them.

It is therefore necessary that the economic growth model at the global level is approached critically within secondary and higher education. The significance of change agents and initiatives at the local level should also made tangible to young people first hand in order that alternative approaches find wider acceptance and the potential to change the current economic paradigm shift is increased. Geography education can play an important role in introducing initiatives which are perceived and disseminated globally. Key concepts such as space, place and scale offer necessary instruments for understanding socio-economic processes and dynamics in a reconstructive way and actively shaping them through applied research (Eberth 2021). Thinking about alternative forms of socially inclusive economic activity is especially relevant when the economy is understood as an expression of culture. "The economy is not only, or even principally, a material entity. It is above all a cultural production, a way of producing human subjects and social orders of a certain kind" (Escobar 2012, 59). In order to achieve an alternative economic worldview, it is necessary to go beyond the goals of SDG 8. By focussing on growth, consumerism and the term "development" fall short of initiating a true paradigm shift towards a just world. Decoupling growth from environmental impact is not enough to create a fair and sustainable economic system. Rather, new ways must be found which can be integrated into secondary and higher education and ultimately raise awareness in society at large.

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SDG 9. Build Resilient Infrastructure, Promote Inclusive and Sustainable Industrialization, and Foster Innovation

Perceived Benefits and Barriers to Cooperation Between Small Farms and Clusters—A Case Study of Poland

Elżbieta Zysk

Abstract Current climate risks, increasing urbanization, decreasing availability of arable land for food production, and the risk of flooding can be seen as potential risks to future global food security. The increase in the global population is yet another challenge facing humanity in the twenty-first century. Urgent steps should be taken to pursue a sustainable agricultural policy and achieve food security, including the cluster policy. Clusters are created to enhance efficiency, competitiveness, environmental sustainability, and enterprise development. A model of linkages between the academia, industry, government, and citizens should be implemented to achieve this goal. Cooperation between clusters and farmers is key to implementing innovative business solutions for smart specialization and sustainable development of regions, to provide modern support solutions for efficient management in agricultural production, implement environmentally friendly technologies, and foster innovation. The aim of this study was to develop a conceptual framework for enhanced cooperation between farmers and clusters and to survey Polish farmers' and experts' perceptions of the benefits and barriers to such collaboration. The final result was a set of competences for cooperation between farmers and clusters, including the specification of agro-clusters. Farmers should have the opportunity to cooperate with agricultural enterprises to implement innovations, improve the efficiency of agricultural production, improve their skills through training, and foster the growth of farms through cluster activities. The present research is a case study of Poland which is one of the largest food producers in the European Union. The research assumptions were validated by analyzing the existing agricultural clusters in Europe and Poland based on a review of the literature, reports, interviews with experts in agriculture, and rural area development, as well as direct research involving small farms (with an area of less than 20 ha). The foundation of the Sustainable Development Goals (SDGs) is blueprint for peace and prosperity for people and the planet, now and into the future. An integral part of the SDGs is the implementation of state-of-the-art innovation, especially in the least developed areas. The discussed concept is fully consistent with the Sustainable Development Goals (SDGs) addressed by European policies,

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_9

in particular Goal 9: Industry, Innovation and infrastructure because cooperation between society/farmers and stakeholders/clusters is key to the implementation of innovation in rural areas and the creation of infrastructure that will support regional economic development with active social participation.

Keywords Small farms · Farmers · Sustainable agricultural policy · Agro-clusters · Agricultural policy

Introduction

The key global challenges of the twenty-first century include growing urban population (Kalnay and Cai 2003; Antrop 2004; Cohen 2006) globalization (van Meijl et al 2006), rapidly growing demand for food (FAO 2012), decreasing availability of cultivable land for food production (Benayas et al 2007; Renwick et al 2013; Olesen and Bindi 2002; Dimitri et al 2005), environmental and climate pressures that threaten agricultural productivity, and current land use practices (IPCC 2014). According to current estimates, food production has to increase by 50–70% by 2050 to meet rising demand and changing food preferences of a growing population, especially the urban population (Boserup 2011) (Table 1). Much of the additional demand for food will originate in regions with high population growth, in particular Sub-Saharan Africa, India, the Middle East and North Africa (OECD/FAO 2019).

By 2050, the world's population will grow to around 9.6 billion people. According to estimates, the global population will increase by 1 billion every 12 years (UN DESA 2018). A growing global population will continue to use increasing amounts of agricultural products for food, feed, and industrial purposes. Many of the world's poorest people will continue to live in rural areas and will depend on agriculture for an important share of their incomes (OECD/FAO 2019). The increase in food production must be achieved from a natural resource base that is declining in quantity and quality (EC 2018) and contributes to climate change (Abson et al 2014) by inducing chemical, physical, and biological processes (Lal 2006) that increase the levels of atmospheric CO_2 (Chase et al 2001) and speed up soil erosion. These processes exert a negative impact on the environment (Pimentel et al 1995). Unsurprisingly, there are now mounting pressures on agriculture to reduce its carbon footprint, and to help mitigate climate change (OECD/FAO 2019).

Table 1 World population

Year	1961	1991	2020
World population	3.073 billion	5.375 billion	7.753 billion
Urban population growth (annual %)	34.12	43.40	56.15
Rural population growth (annual %)	65.87	56.60	43.85

Source The World Bank Group (2021)

International norms such as the Millennium Development Goals (UN 2000) and Sustainable Development Goals (UN 2015a, b) (FAO 2012a, b) postulate sustainable rural development. The Common Agricultural Policy postulates that sustainable rural development can be achieved by focusing on a limited number of key priorities relating to the transfer of knowledge and innovation in agriculture at the EU level (Regulation (EU) No 1305/2013). The transfer of knowledge and innovation in agriculture can be facilitated through clustering and data and experience sharing. Clusters are created to increase efficiency, competitiveness, environmental sustainability, and enterprise development. They enhance the effectiveness of agricultural production through innovation and the implementation of smart specialization. A model of linkages between the academia, industry, government and citizens should be implemented to achieve this goal. The framework of action should be organized around citizens-farmers and clusters.

The aim of this study was to develop a conceptual framework for enhanced cooperation between farmers and clusters and to survey Polish farmers' and experts' perceptions of the benefits and barriers to such collaboration. Farmers should have the opportunity to cooperate with agricultural enterprises, implement innovations, improve the efficiency of agricultural production, improve their skills through training, and foster the growth of farms through cluster activities. Cooperation between clusters and farmers is crucial for implementing innovative business solutions for smart specialization and sustainable development of regions, to provide modern support solutions for efficient management in agricultural production, implement environmentally friendly technologies and foster innovation.

A review of the literature indicates that cooperation between institutions and local communities fosters technological progress and contributes to policies that support the sustainable development of regions. This is an important objective because agriculture needs guidance for improved cooperation under Goal 9 of the Sustainable Development Goals formulated by the United Nations General Assembly in 2015 (UN 2015a, b). The foundation of the Sustainable Development Goals (SDGs) is blueprint for peace and prosperity for people and the planet, now and into the future. An integral part of the SDGs is the implementation of state-of-the-art innovation, especially in the least developed rural areas.

Cooperation between society/farmers and subjects/clusters is key to implementing innovation in rural areas and the creation of infrastructure that supports the economic development of regions with active social participation. Clusters enable farmers to improve the efficiency of agricultural production through innovation and the implementation of smart specialization. A model of linkages between the academia, industry, government, and citizens should be implemented to achieve this goal.

The progress made in the implementation of the above goals will be assessed based on an analysis of the existing clusters in Europe and in Poland in view of published reports and a review of the literature. The existing clusters will be analyzed to obtain background information, identify the main clusters and their area of activity in Europe and Poland. Agricultural cluster policy at the regional level and the relevant solutions and barriers will be identified based on a literature interview and interviews with agricultural policy experts from selected institutions. The panel of experts included civil officers from agricultural institutions (Voivodeship Marshals' Offices and the Agency for Restructuring and Modernization of Agriculture). In the last stage of the study, a questionnaire survey was conducted in the Polish voivodeship of Warmia and Mazury to identify small farmers' (with farm area of less than 20 ha) perceptions of the benefits and barriers to cooperation with clusters. The results were used to optimize the distribution of competences for cooperation with farmers and clusters, including agro-clusters. The proposed solution advocates for the establishment of specialist institutions responsible for eliminating barriers and monitoring the farmers' ability to implement the expected benefits of collaboration.

Materials and Methods

Materials

Poland is one of the largest EU countries that lies at the geographic center of the European continent. Its central location and well-developed road, railway, and aviation infrastructure guarantee easy access to both Western and Eastern European markets. The Polish railway network spans a combined length of 20,228 km and is one of the densest railway systems in the world. Poland also operates numerous sea and trade ports (including in Szczecin, Świnoujście, Gdynia and Gdańsk) which have connections with the most important ports all over the world (Cluster 2016). Poland was selected for the study because it belongs to a group of EU countries with the highest number of agricultural holdings and is one of the largest food producers in Europe. The voivodeship of Warmia and Mazury was selected for detailed analysis.

Political, social, and economic data were gathered in the first stage of the study to set the background for detailed analyses. The collected data are presented in Table 2.

Food production in Poland has increased by more than 57% since 2010, and more than 40% of domestic food production is exported (CSO 2018). The supply of agricultural raw materials and foodstuffs exceeds domestic consumption and guarantees national food security (CSO 2018; SYA 2018). Poland was selected as a model country for this study due to the economic and social implications of national food security. According to the Statistical Yearbook of Agriculture (SYA 2018), the majority of Polish agricultural holdings are small farms under 20 ha, and this group of farms was selected for the study.

Methods

In the first stage of the study, the clusters operating in Europe and Poland were identified and quantified, and their regional characteristics were described based

Table 2 General statistical data on Poland and Polish agriculture

General location and area	Europe/31.3 million ha
Poland area (km)	312,696
Administrative division	Voivodships–(16); District level–counties (380); Local level–municipalities (2478)
Total area of agricultural land	14.62 million ha
Population (2018) (in thous.)	38,411
/population density	/123/ km^2 (CSO 2016)
Including in rural areas (in thous.)	15,344
Land (2018) (in thous. ha) including:	31,269.6
Agricultural land	18,776.5
Forests, land under trees and bushes	9534.2
Land under water	652.0
Mineral excavation sites	29.1
Transport networks	938.7
Residential areas	747.5
Fallow land	465.0
Voivodship of Warmia and Mazury (2018)	
Total area	2,417,347
Agricultural land	1,316,212
Arable land	874,588
Orchards	2516
Permanent meadows	160,560
Permanent pastures	222,129
Built-up agricultural land	26,878
Land under ponds	2599
Land under ditches	10,240
Land under trees and bushes	16,702
Forests and land under trees and bushes	791,007
Farms by size (in percent) (2017)	
up to 1 ha	1.5
1.01–1.99	18.7
2.00–4.99	32.0
5.00–9.99	22.5
10.00–14.99	10.1

(continued)

Table 2 (continued)

15.00–19.99	5.0
20.00–49.99	7.7
50.00 ha and more	2.5
Rural population	
Voivodeship of Warmia and Mazury	587,523
Population density	25 km^2

Source Own elaboration based on the Statistical Yearbook of Agriculture (SYA 2018)

on a review of the literature. In the following stage, interviews were conducted with 10 experts responsible for agricultural policy and regional development in the Marshal's Office, the Agency for the Restructuring and Modernization of Agriculture (ARMA), and the National Support Center for Agriculture (NSCA). The last stage of the research involved a survey of farmers to identify the perceived benefits and barriers to cooperation with clusters. The survey was conducted using the direct interview method. The questionnaire was developed based on Sustainable Development Goals (SDGs), specifically Goal 9: Industry, Innovation, and Infrastructure (UN 2015a, b; UN DESA 2018; Regulation (EU) No 1305/2013; Regulation (EC) No 138/2004; FOOD 2019). The questionnaire contained 25 questions, mostly closed-ended, single-choice questions. The survey involved 180 small farmers in the Polish voivodeship of Warmia and Mazury.

Literature Review

Definition of a Cluster

A cluster is defined as "a geographic concentration of industries which gain advantages through co-location" (Bosworth and Broun 1996) or "geographic concentrations of group of firms with similar products or services, agglomerated and interconnected companies and institutions in a particular field" (Porter 1998). Many clusters include governmental and other institutions, such as universities, standard-setting agencies, think tanks, vocational training providers, and trade associations that provide specialized training, education, information, research, and technical support (Porter 1998). The companies participating in clusters generate public benefits and factor inputs, and they contribute to the dissemination of knowledge (Marshall 1920; Kalnins and Chung 2004; Alcácer and Chung 2007; McCann and Folta 2008; Porter 1998). Clusters can be described as geographical agglomerations of mutually related companies, specialized suppliers, service providers, companies operating in similar sectors and related institutions that both cooperate and compete with each other. The potential of clusters and cluster initiatives in a given country is determined by

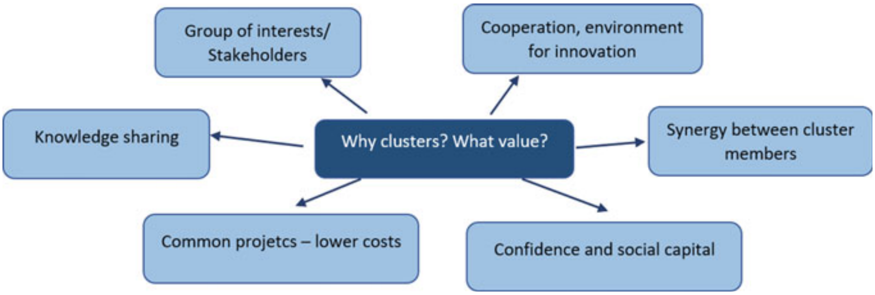


Fig. 1 Definition and value of clusters. *Source* own elaboration

numerous factors, including the business environment and the presence of institutions promoting enterprise growth (Cluster 2016). In the literature, clusters are defined as the geographic concentration of independent entities from different sectors of the economy that cooperate and compete with each other within the value chain. A cluster generates benefits and creates new value for its participants, including enterprises, universities, research organizations, business environment institutions, public administration, and other supporting organizations (Directions 2020). The definition and the value of clusters are presented in Fig. 1.

Clusters strengthen their competitive advantage by combining inter-firm rivalry, collaboration (co-opetition), and innovation (Verdú and Tierno 2019) with rapid transmission and adoption of ideas, generation of important local externalities such as skilled labor, availability of specialized inputs, including physical, technical and legal (such as those relating to certification), and enhanced access to information on technologies and markets (FAO 2010).

Similar assumptions apply to agribusiness sector companies that support small farms. Agribusiness clusters involve producers, agro-industries, traders, and other private and public actors that are interconnected, engaged in the same industry, build formal or informal value networks, address common challenges, and pursue common opportunities in rural areas (FAO 2010). According to FAO (2010), strategies targeting agribusiness and agro-industry development improve the competitiveness of agribusinesses, in particular small- and medium-sized companies (FAO 2010). Agribusiness can undertake new ventures with clusters to maximize their competitive advantage on the local market (Porter 1998). Innovation significantly influences the competitiveness of geographic clusters. The relationships between geographic location and innovation have been studied extensively (Asheim and Isaksen 1997; Baptista and Swann 1998, Baptista 2000, 2001). According to Joly (2011), new ideas, new technical devices, or new forms of organization are developed to meet user needs. The World Bank defines innovation as a process by which individuals or organizations master and implement the design and production of goods and services that are new to them, irrespective of whether they are new to their competitors, their country, or the world (World Bank 2006). Innovations are introduced through systems or networks of individuals and organizations to ensure that new practices and processes are successfully adopted (Akrich et al 2002; Schumpeter 1962). The success of innovation efforts requires the development of a conceptual framework, which entails cooperation between community members and entities responsible for the implementation of innovations (Cohen and Levinthal 1990; Lawson and Samson 2001). In rural areas, innovations are introduced by clusters, and the local community is represented by farmers (Zysk et al 2020). Cooperation between clusters and farmers is key to implementing innovative business solutions for smart specialization and sustainable development in the region and on farms. It contributes to the introduction of modern solutions for more efficient management in agricultural production and the implementation of environmentally friendly technology, and it fosters innovation. These measures are undertaken to promote sustainable development, including regional and economic development with active social participation. The factors that contribute to the effective operations of clusters and cooperation with farmers have to be identified to broaden the existing knowledge and facilitate the achievement of sustainable rural development goals, including Goal 9. Cluster activities should be analyzed to monitor the progress toward sustainable rural development (Fig. 2).

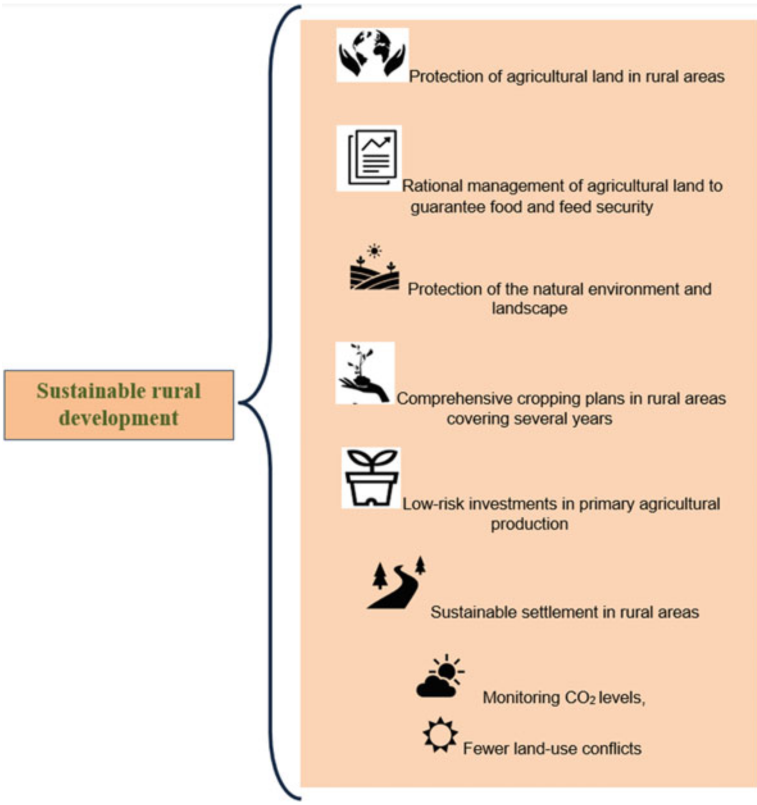


Fig. 2 Sustainable rural development. *Source* Own elaboration

To achieve the main research objective, clusters in the EU and Poland were analyzed in the first stage of the study. The analysis was based on a review of the literature and the relevant documents (Cluster 2016, 2018; Directions 2020; EPCICh 2020).

Field Research

Clusters in Europe

European clusters were mapped and evaluated in the 2020 edition of the European Panorama of Clusters and Industrial Change report (EPCICH 2020) developed by the European Observatory for Clusters and Industrial Change. The results are presented in Fig. 3.

The report presents the geographic location of clusters across 51 exporting industry sectors in Europe. It analyzes cluster strength and divides clusters into basic-performing, medium-performing, and high-performing regional clusters (Table 3).

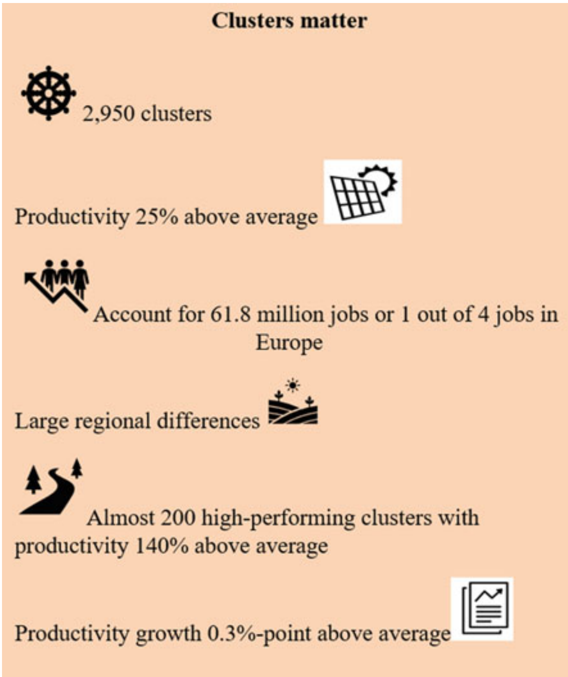


Fig. 3 Characterization of European clusters. *Source* own elaboration based on EPCICh (2020)

Table 3 Top-25 regions with most clusters

	NUTS code	Region	Basic-performing clusters	Medium-performing clusters	High-performing clusters	Total number of strong clusters
1	FR10	Ile-DE-France	10	30	3	43
	ITC4	Lombardia	20	21	2	43
3	ES51	Cataluña	31	9	1	41
4	ITH3	Veneto	22	15	0	37
5	ES30	Madrid	24	10	2	36
	ITC1	Piemonte	14	15	7	36
7	ITI1	Toscana	21	12	1	34
8	ES52	Comunidad Valenciana	26	7	0	33
	FR71	Rhone-Alpes	22	9	2	33
10	ITH5	Emilia-Romagna	20	11	1	32
		Stockholm	16	14	2	32
12	ES61	Andalucia	23	8	0	31
13	DEA1	Duesseldorf	11	14	4	29
	ITF3	Campania	13	14	2	29
	ITI4	Lazio	15	13	1	29
16	DE11	Stuttgart	15	6	7	28
	ES21	PaísVasco	9	16	3	28
	PL12	Mazowieckie	11	17	0	28
19	DEA2	Köln	10	12	5	27
20	DE21	Oberbayern	22	4	0	26
	IE02	Southern and Eastern	14	8	4	26
22	UK13	Inner London-West	20	5	0	25
23	BE23	East-Flanders	15	9	0	24
	HU	Central Hungary	17	4	3	24
	PL41	Wielkopolskie	17	5	2	24

Source own elaboration based on EPCICh (2020)

A total of 2950 regional industrial clusters have been identified across Europe, including 198 high-performing clusters, 898 medium-performing clusters, and 1854 basic-performing clusters (EPCICh 2020). Fifty-five clusters have been identified in the sector of Agricultural Inputs and Services, including one high-performing, 11 medium-performing, and 43 basic-performing clusters. The high-performing cluster is located in the UK (Lincolnshire). Medium-performing clusters are located in Germany (Schleswig–Holstein), Spain (Aragon, Castilla-La Mancha, Comunidad

Valenciana, Andalucía, Murcia), France (Champagne-Ardenne, Bourgogne, Pays-de-la-Loire, Bretagne), and Norway (Hedemark og Oppland). Basic-performing clusters are located in Belgium (1 region), Czechia (4 regions), Denmark (1 region), Germany (4 regions), Greece (4 regions), Spain (3 regions), France (5 regions), Italy (4 regions), Hungary (2 regions), Poland (2 regions), Portugal (2 regions), Romania (4 regions), Slovakia (1 region), Sweden (1 region), the UK (2 regions), Switzerland (1 region), and Norway (2 regions).

Clusters in Poland

Poland is referred to as the economic heart of Europe. Poland is a rapidly developing country and clusters undoubtedly contribute to the growth of the Polish economy. The number of Polish clusters has increased in recent years. The distribution of clusters in Polish voivodeships is presented in Fig. 4.

The location of clusters reflects the economic potential of Polish regions because 48% of clusters are located in the four most developed regions: Mazovia, Lower Silesia, Wielkopolska, and Silesia. Key National Clusters (KNCs) are defined as clusters that are of crucial importance for the national economy and are highly competitive in the international arena. Polish KNCs and their potential are presented in Fig. 5 (Fig. 6).

The group of 134 analyzed clusters represent a wide variety of industries, from traditional to high-tech, and a total of 28 specializations were identified. Many clusters belong to ICT, energy, construction, tourism, production technology, and agricultural sectors. Furniture, clothing, machinery, wood, nanotechnology, geodesy, pharmacy and cosmetics, and maritime economy sectors are represented by one cluster each.

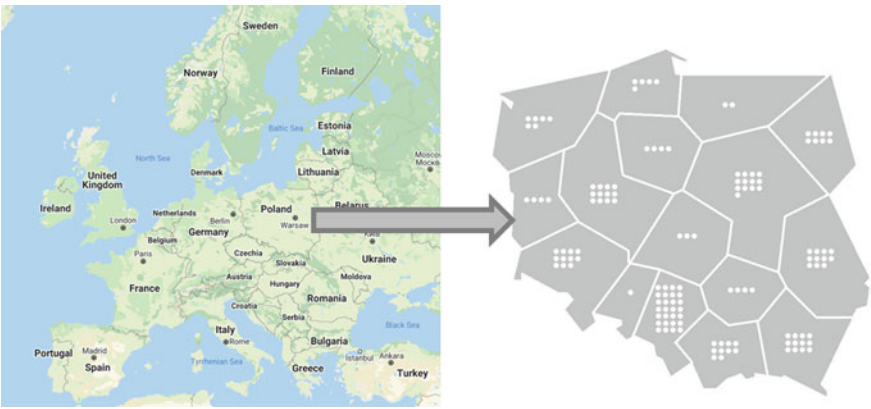
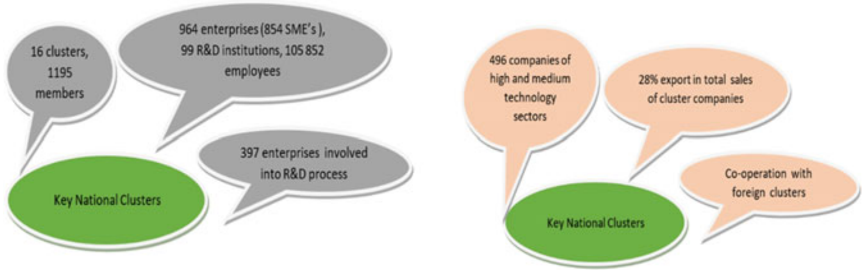


Fig. 4 Location of clusters in Poland. *Source* own elaboration (Cluster 2016)



Key National Clusters in Poland
potential

Cluster

Fig. 5 Polish Key National Clusters and their potential. *Source* own elaboration based on Cluster Policy in Poland (Cluster 2018). The KNCs belong to many industrial sectors, and they are not uniformly distributed across Polish regions (Fig. 6)

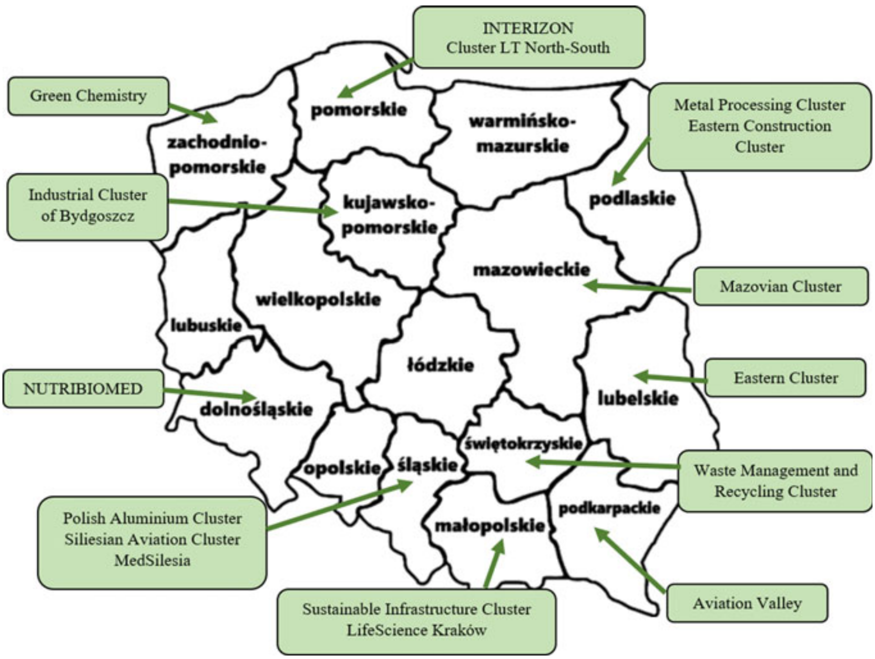


Fig. 6 Key National Clusters by voivodeship in Poland. *Source* own elaboration

Polish clusters were also analyzed across different sectors and smart specializations in agriculture in each region. The smart specialization concept relies on scientific and technological innovation. Smart specialization can have different definitions, depending on the approach adopted in a given region. Some smart specialization strategies promote the growth of the existing industries and economic sectors,

Table 4 Industrial sectors and smart specializations in Polish voivodeships

Voivodeship	Sector	Smart specialization
Kujawsko-Pomorskie (*Kuyavian-Pomeranian*)	Food industry	Safe food and agriculture
Lubelskie (*Lublin*)	Food industry	–
Łódzkie (*Łódź*)	–	Innovative agriculture and agri-food processing
Mazowieckie (*Masovian*)	Food security	
Opolskie (*Opole*)	–	Agri-food processing technology
Podkarpackie (*Subcarpathian*)	Food industry	–
Podlaskie (*Podlasie*)	–	Agri-food industry and sectors in the value chain
Świętokrzyskie (*Holy Cross*)	–	Modern agriculture and food processing
Warmińsko-Mazurskie (*Warmian-Masurian*)	–	Water management and high-quality food
Wielkopolskie (*Greater Poland*)	Food industry	Bioresources and food for conscious consumers

Source own elaboration

whereas others combine numerous sectors or are related to specific technologies. Industrial sectors and regional smart specializations are not always consistent with the classification of smart specializations in agri-food production and agriculture at the national level (Table 4).

Poland has significant agricultural capital, and it is one of the leading food producers in the European Union. The food industry, food production, and agriculture are the predominant sectors and smart specializations in 10 Polish voivodeships. Smart specializations were directly linked with the relevant industrial sectors in only two voivodeships (Kujawsko-Pomorskie and Wielkopolskie). The clusters in Podkarpackie and Lubelskie voivodeships operated in the food processing sector, and the clusters in Mazowieckie voivodeship operated in the food security sector. In the remaining voivodeships, smart specializations were related to the food industry and agriculture. These findings indicate that agriculture is an important sector of the Polish economy, and that clusters, sectors, and smart specializations will pave the road to the future development of Polish voivodeships. The relevant measures and activities require effective policies targeting agribusiness clusters.

Expert Survey—Policies Targeting Regional Agribusiness Clusters—Opportunities and Barriers

The survey involved direct interviews and telephone interviews with 10 experts responsible for agricultural policy and regional development at the Marshal's Office, the Agency for the Restructuring and Modernization of Agriculture, and Agricultural Advisory Centers in the voivodeship of Warmia and Mazury. The respondents were of the opinion that effective cluster policies, in particular policies targeting agro-clusters, were not available. This observation suggests that a general framework should be established for evaluating regional policies that are responsible for grass-roots initiatives such as agro-clusters. According to the experts, smart specializations in agriculture can be partly identified based on an analysis of regional clusters. A model of cooperation between local governments, businesses and stakeholders could be developed by creating regional platforms for the exchange of experiences and good practices. Financial support is also an important issue. Clusters and their members should have access to financial instruments dedicated to farmers who have an interest in improving their professional qualifications and implementing innovative solutions in their farms. These financial instruments should be available at the regional level.

The offices of voivodship marshals could participate in such initiatives by communicating important information about cluster operations and cluster policies (meetings, workshops, conferences) on dedicated Web sites, and by organizing events, missions, study tours, and information centers. Various incentives and support measures should be initiated to encourage farmers to implement innovative solutions in agricultural production and in their farms. Dedicated Web sites containing information about agricultural cluster policies, projects, members, and membership options could also promote the establishment of regional clusters. According to the surveyed experts, promotional measures contribute to the development of clusters and influence the operations of individual farmers. Clusters should be promoted not only on local and regional markets, but also in the international arena to facilitate cooperation with high-performing clusters. Collaboration between clusters, including the commercialization of research results, networking, and the creation of project consortia, is also an important consideration. To promote the growth of clusters, effective intellectual property policies is needed to protect innovative solutions and novel products. The proposed measures will improve the status of local farms, promote the development of cluster members, and drive innovation in agro-clusters.

Farmer Survey

The survey involved 180 farmers in the voivodeship of Warmia and Mazury. The size of the surveyed population was dictated by the number of farmers who could be directly accessed. The survey was conducted in line with international standards

Table 5 Characterization of the respondents

Parameter	Total
Number of farms: • farms with an area of up to 20 ha	180
Sex: Women Men	154 26
Age: 18–34 35–54 55 +	20% 35% 45%
Average farm area in ha up to 2.9 ha 3–4.9 ha 5–9.9 ha 10–19 ha 20 ha	11% 14% 20% 25% 25%
Percentage of respondents who recognized the benefits of cooperating with clusters	77.1%
Percentage of respondents who identified the barriers to cooperation with clusters	51.2%

Source own elaboration

applicable to Sustainable Development Goals, in particular Goal 9: Industry, Innovation and Infrastructure, as well as a review of the solutions implemented in other countries, including Germany (Pölling et al 2017). In the questionnaire, the respondents were asked to identify the expected benefits and barriers to cooperation with clusters. The respondents are characterized in Table 5.

The majority of the surveyed farmers were 55 and older. Most respondents owned farms with an area of 10 ha to more than 30 ha. More than 77% of the farmers were of the opinion that cooperation with clusters could deliver benefits, whereas the barriers to such cooperation were identified by more than 51% of the respondents. The perceived benefits of cooperation within clusters are presented in Table 6.

The survey revealed that farmers recognized the benefits of cooperation within clusters. Most respondents were of the opinion that cluster membership can deliver financial benefits, increase farming incomes, facilitate the implementation of innovative solutions and new technologies, and expand the farm's productive output. Every fourth farmer expected the implementation of environmentally friendly solutions. It should be stressed that according to the respondents, cooperation with clusters could improve resource use efficiency, decreases costs, promotes specialization, and facilitates the introduction of new types of agricultural production. Other identified benefits included the possibility of selling products when the prices of agricultural commodities are highest, generation of off-farm incomes (agricultural services), and enhanced competitive advantage.

These findings confirm that agro-clusters expert a positive impact on farm operations. By cooperating with clusters, farmers can expect to improve their performance and expand agricultural operations. According to the respondents, cooperation with

Table 6 Perceived benefits of cooperation within clusters

Benefits	Respondents (%)
Financial benefits	40
Innovation and new technologies	32
Increased agricultural production	30
Implementation of environmentally friendly solutions	24
Improved resource use efficiency	22
Specialization	20
New type of agricultural production	15
Selling products when the prices of agricultural commodities are highest	10
Off-farm income (agricultural services)	9
Lower production risk	5
Access to new markets (agricultural commodity exchange, food processing companies)	5

Source own elaboration

agro-clusters not only delivers financial benefits, but it also promotes the implementation of innovative solutions and specialization, thus expanding productive output and improving the efficiency of agricultural production.

The respondents also identified the barriers to cooperation with clusters. The results are presented in Table 7.

The vast majority of the surveyed farmers identified several barriers to cooperation with agro-clusters. The most frequently identified obstacles were the absence of previous experience of cooperating with clusters, lack of incentive, insufficient information about cluster membership, no contact persons for communicating with

Table 7 Barriers to cooperation with clusters

Barrier	Respondents (%)
No previous experience of cooperating with clusters	30
No incentive to cooperate with clusters	25
Insufficient information about cluster membership	20
No offers of membership	19
No contact person for communicating with farmers	18
Excessive formal requirements	15
Membership offer does not match the farm's profile	14
No need to cooperate with a cluster	10
Cluster is located far from the farm	9
High service costs	4

Source own elaboration

farmers, excessive formal requirements, and the lack of perceived need to cooperate with clusters.

The lack of previous experience and the absence of incentives for cooperating with clusters could indirectly indicate that agro-clusters are not highly active on local markets. Clusters that actively encourage farmers to cooperate can significantly contribute to the development of social capital in rural areas and promote entrepreneurial and active attitudes. The fact that the respondents expected to be personally addressed by clusters could indicate that some farmers do not directly recognize the potential benefits of cooperating with agro-clusters. Many farmers lack the knowledge about agro-clusters' competences and field of operation. Therefore, clusters should initiate promotional activities to distribute such information and encourage farmers to cooperate.

The results of the survey indicate that members of agro-clusters can play a very important role in eliminating barriers to effective cooperation with farmers. Possible solutions to improving the collaboration between farmers and agro-clusters are proposed in the next section.

Solutions for Improving Cooperation Between Farmers and Agro-clusters

The results of the present study suggest that agro-clusters are responsible for some of the barriers to cooperation with farmers. Many clusters do not offer incentives that could encourage farmers to cooperate. The lack of personalized incentives motivating individual farmers to join agro-clusters is one of the reasons for farmers' passive stance. Farmers are reluctant to become cluster members because they lack the knowledge about possible benefits. Agro-clusters do not employ dedicated personnel who would assist potential members in filling in the required documentation and encourage farmers to become members. Some farmers do not see the need to work with clusters, do not have sufficient knowledge about cluster operations, and are unable to access the relevant information online due to the absence of dedicated offers. Farmers often lack to time to search for new opportunities because farm work is a full-time job that occupies most their waking hours. In view of the above, the authors proposed a solution that would enable clusters to effectively channel their resources and distribute responsibilities for cooperating with farmers. The developed system would facilitate the flow of information between agro-cluster businesses and potential members. As part of the proposed solution, members of agro-clusters would share responsibility for eliminating the existing barriers and incentivizing farmers to join the cluster. The designed system also features dedicated units that would be responsible for field operations and direct communication with farmers. A diagram illustrating the structure of the proposed system for cooperation with farmers is presented in Fig. 7.

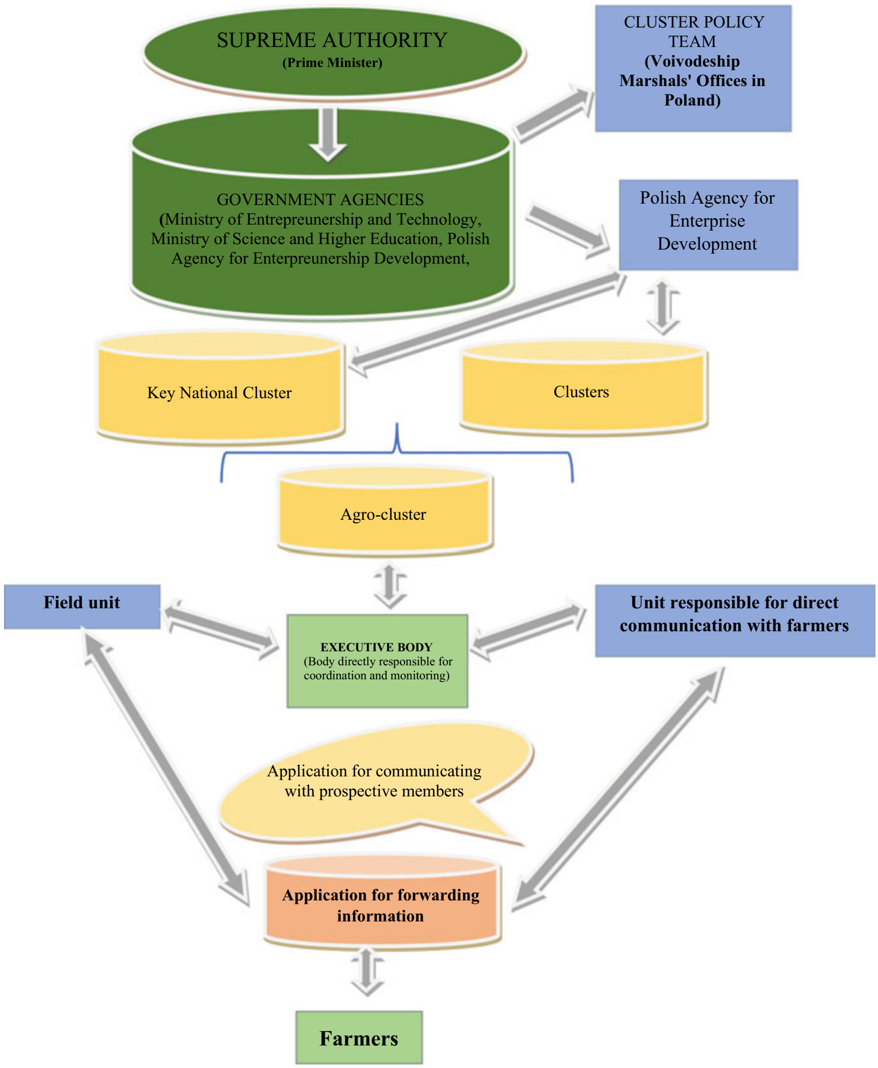


Fig. 7 Distribution of responsibilities to facilitate cooperation between agro-clusters and farmers. *Source* own elaboration

In the proposed system, the distribution of competences was arranged in a hierarchical order, and entities that play a key role in communication with farmers were identified. The division of management tasks from the macro- to the micro-scale supports effective coordination of activities aiming to expand cluster membership (Duczkowska-Piasecka 2012).

The developed system features supervisory, executory, and advisory bodies. The Prime Minister is the supreme authority who supervises the operations of government agencies (Ministry of Entrepreneurship and Technology, Ministry of Science and Higher Education, Polish Agency for Entrepreneurship Development, National Center for Research and Development), the Cluster Policy Team as an advisory body responsible for cluster policy (for example, Marshal's Offices in Polish voivodeships), an executive body (Polish Agency for Enterprise Development), Key National Clusters and clusters. Agro-clusters constitute a separate category in the existing group of clusters. Each agro-cluster would establish an executive body that would be directly responsible for monitoring and coordinating the relevant measures. Executive bodies would monitor the performance of units that are directly responsible for communicating with farmers as well as field units. This division of responsibilities would speed up communication and improve cooperation with farmers. The system also features a dedicated application that would speed up communication and enable farmers to submit the required information to clusters.

Conclusions

The future of the European Union rests on economic and social cooperation between the Member States. This assumption should also be applied to the operations of clusters, including agro-clusters. Agro-clusters are a link that combines agricultural production with commerce, science, consumers, and government institutions. The present study demonstrated that clusters play an important role in EU policy, including in Poland. These findings are important because the identified benefits and barriers to cooperation between farmers and agro-clusters can be used to implement solutions that promote effective collaboration on the agricultural market. By joining agro-clusters, small farmers can strengthen their position in the food supply chain, establish cooperation with new partners, reach new markets, and increase their competitive advantage by implementing innovative solutions and new technologies.

In the proposed division of competences, agro-clusters would create dedicated units that would be responsible for direct communication with farmers and would eliminate barriers to cooperation between farmers and clusters. Farming is a time-consuming occupation, and the developed system would feature an application that would enable farmers to submit the required information to clusters and minimize formal reporting requirements. Farmers who become members of agro-clusters can benefit from economies of scale by stabilizing their market position, promoting their products together with other members of the cluster, and increasing production profitability. Cooperation with clusters enables farmers to implement innovative technological solutions in agricultural production and decrease production costs by negotiating discounts on bulk purchases of fertilizers, pesticides, and machines.

The proposed measures can strengthen cooperation between farmers and agro-clusters which play an important role in economic policy. The economic policies of the EU Member States should combine regional and industrial policy tools to promote the implementation of smart specialization strategies. Smart specialization programs support regional development. Clusters play an important role in the implementation of smart specialization strategies in European regions.

Smart specialization in European regions contributes to food security. Food security policies should rely on cooperation between government agencies, agro-clusters, and producers of agricultural commodities (farmers). The proposed system for the distribution of competences and responsibilities will eliminate barriers to collaboration between farmers and clusters and will contribute to the achievement of Sustainable Development Goals in Europe, in particular Goal 9: Industry, Innovation, and Infrastructure. Effective cooperation between state institutions, research centers, agro-clusters and farmers enables the introduction of modern solutions in agriculture, promotes environmentally friendly technologies, and fosters innovation.

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SDG 10. Reduce Inequality Within and Among Countries

Spatial Disparities: An Approach to Reveal "Hidden Areas" to Territorial Development in the Marrakech-Safi Region—Morocco

Salima Salhi, Said Boujrouf, and Abdelali Gourfi

Abstract At the global level, the issue of combating spatial inequalities is the subject of considerable debate and public interest. However, the consideration of the local level in the measurement of regional disparities is often neglected. The objective of this work is to study spatial inequalities in Morocco using the case of the Marrakech-Safi region. To do so, the different indices of multidimensional territorial development (IDTM) were collected (level of education, economic activity, health status, housing condition, living environment and distribution of social services). A statistical analysis using Principal Component Analysis (PCA) and a Hierarchical Ascending Classification (HAC) was carried out, thereafter, in order to understand and bring out the existing relationship between the different deficits. We also used the GIS tool to process and represent the results obtained. These results reveal the existence of a strong spatial disparity at the communal and provincial levels. A strong relationship is noted between two indices that show a large deficit, the one related to "standard of living" and the one related to "education", "housing" and "social services". The deficit in the education index also conditions the deficit in "social services" and "housing". Several factors influence the values of these indices. It should be noted that the areas with the highest level of disparities are the territories where the natural obstacle is more important, such as in the mountainous areas of the Western High Atlas, suffering from a lack of water resources and deficient in terms of road accessibility. The results obtained could be mobilized by the various actors and especially the public authorities to carry out more effective actions for

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_10

the territorial development of the studied areas. The method used in this study could also be useful as a practical scientific approach for other regions of Morocco.

Keywords Spatial disparities · Territorial development · Social deficits · Multidimensional development index · Quantitative and GIS approach

Introduction

Spatial disparities are the result par excellence of the intersection of economic and social indices or variables of income, activities, facilities and development potential (Kochendorfer-lucius et al. 2009). In many countries, it is the observation of such disparities that could lead to the implementation of a regional planning policy aimed at achieving regional balance (Choay 1988; Rodríguez-Pose and Hardy 2015; Kumar and Rani 2019). Regional inequality remains a global phenomenon, even more severe in developing countries. According to Myrdal (1957), favoured areas develop at the expense of underdeveloped areas. However, the role of the state is essential to reduce spatial disparities. Ezcurra and Rapún (2006) also proved that the development path at the country level is almost never equitable at the regional level, between urban and rural areas as pointed out by Cour (2007); Chaudhuri and Roy (2017); Cheng et al. (2019), between plains and mountains (Boujrouf 2002; Boujrouf and Giraut 2000), between coastal and continental areas (Catin and Van Huffel 2004), between regions and communes within the same region (Shefer and Antonio 2013) and between douars (*Basic administrative division in North Africa; territorial fraction of the commune*) in the same commune (Randolph and Currid-Halkett 2021). Studies by several researchers, among them (Koropeckyj 1972; Mastronardi and Cavallo 2020), have shown that national development is generally accompanied by an increase in inequalities between regions, provinces and municipalities in many countries. Thus, spatial disparities are an important challenge to development (Easterly 2007).

However, the measurement of spatial disparities is a very delicate matter, it does not depend on a single indicator or index, but rather on the fusion of several indicators (economic, social, environmental, spatial and sometimes even cultural), which give a global vision of the territory studied by showing its inequalities. However, they have a complementary relationship between them (Chakravorty 1996; Novotný 2007; Breau and Saillant 2016; Kim et al. 2020).

This article examines spatial disparities in the Marrakech-Safi region, one of the twelve regions of Morocco, considered among the regions whose development index (0.67) is significantly lower than the national average (0.7). The areas most affected by the negative effects of disparities are remote rural areas and mountainous areas that are difficult to access and under-equipped. Among the eight provinces that make up the Marrakech-Safi Region, Marrakech is positively confirmed ahead of the other provinces with a development index higher than the national average (0.8). Thus, the study region represents a good example for the study of spatial disparities as an undeniable result of gaps in local development actions.

The method engaged in this work is multidimensional calculation of territorial development index. It is based on the processing of various data from the last general census of population and housing in Morocco of 2014 by combining the method of calculating multidimensional indices used by *the National Observatory of Human Development* (NOHD 2017). Principal Component Analysis (PCA) and Hierarchical Ascending Classification (HAC) were mobilized to find the relationship between the different deficits in human and social development, as well as their spatial distribution.

The objective of this work is to promote a new method of calculating and representing spatial and territorial inequalities based on territorial communities (communes) as the basic statistical unit in Morocco. Moreover, taking the spatial dimension into account is justified by the existence of a strong link between spatial location and disparity. To this end, finer geographic targeting, starting at the commune level, could make the various actors aware of the need to take it into account in their decision-making in the context of regional development policies.

The Marrakech-Safi Region: A Relevant Space to Study Spatial Disparities

Covering an area of 39,157 km^2 (4.5% of the territory of Morocco), the region of Marrakech-Safi is one of the twelve regions of Morocco. It is located in the centre of the country and encompasses a variety of reliefs with a part of the mountains composed of the Western High Atlas, the plain of Haouz and Sraghna, the plateaus of Abda, Chiadma, Haha, Guentour, Rhamna and Jbilet. This region is inhabited by a population of about 3 million inhabitants, a density of 115 hab/km^2 and an urbanization rate of 42.8% (General Census of Population and Housing 2014). Bounded to the north by the region of Grand Casablanca-Settat, to the east by the region of Beni Mellal-Khénifra, to the southeast by the region of Drâa-Tafilalet, to the south by the region of Souss-Massa and to the west by the Atlantic Ocean.

The geographical and natural setting of the region (Fig. 1) is characterized by great diversity, with an arid to semi-arid climate that remains subject to the influences of the Atlantic Ocean and the very high altitudes of the High Atlas. The inland areas of the region experience a cold winter with low rainfall and a hot, dry summer, with a vegetation cover that extends over an area of 721,876 ha, which represents 22.6% of the national total, including nearly 65,120 ha of artificial forest and fruit plantations. The region is characterized by low altitudes in the north and centre and high in the south. The hydrographic network is concentrated in the central part with an East–West orientation, taking as source the mountains of the Western High Atlas (SUD). The road network in the region of Marrakech-Safi totals 18,144 km of which 15,342,071 km are tarred and 2,802,228 km are in track condition. The most equipped areas of the region are essentially the urban centres, especially Marrakech, Safi, El Kalaa des Sraghna and Essaouira.

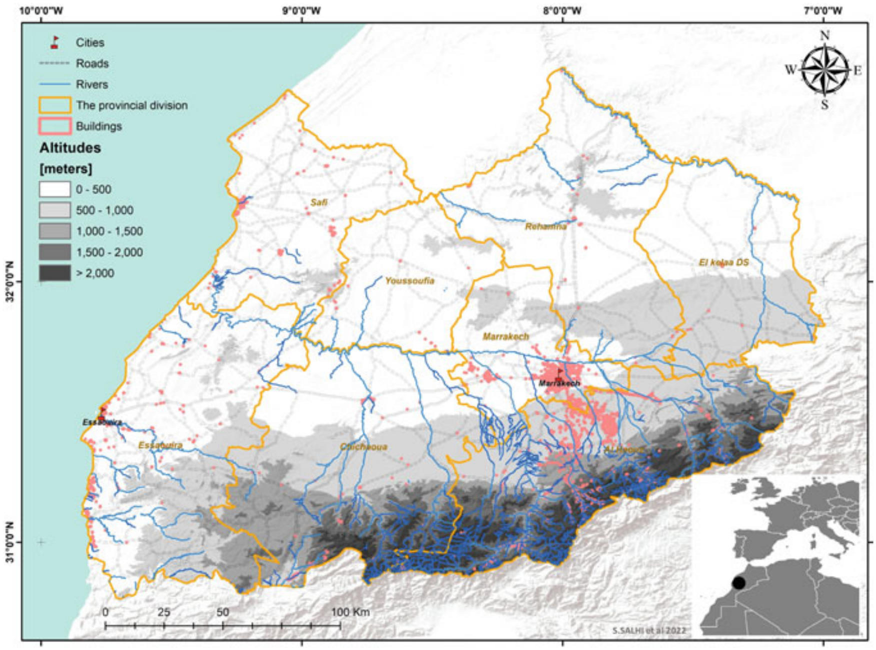

Fig. 1 Geographic setting of the study area

The region has seven provinces and one prefecture: Chichaoua, Al Haouz, El Kelâa des Sraghna, Essaouira, Rehamna, Safi, Youssoufia and the prefecture of Marrakech. The number of communes is 215, of which 18 are urban and 197 are rural, i.e. about 14% of all communes at the national level (Fig. 2).

The active population rate is 47.2%. However, the region has an unemployment rate of 13.1%, with an illiteracy rate of 37.8% and a poverty rate of 11.3% (according to General Census of Population and Housing 2014).

Methodology

The methodology adopted (Fig. 3) consists of calculating the multidimensional territorial development index (MTDI) of the territorial authorities, namely the communes (MTDIC) and the provinces (MTDIP) that make up the Marrakech-Safi region, based on the data of the general census of population and housing in Morocco of 2014. A statistical analysis by Principal Components (PCA) and Hierarchical Ascending Classification (HAC) was performed, in order to find the existing relationship between the deficits in social and human development; finally, the spatial distribution of the results was elaborated in the form of graphic representations developed from a GIS dedicated to this task.

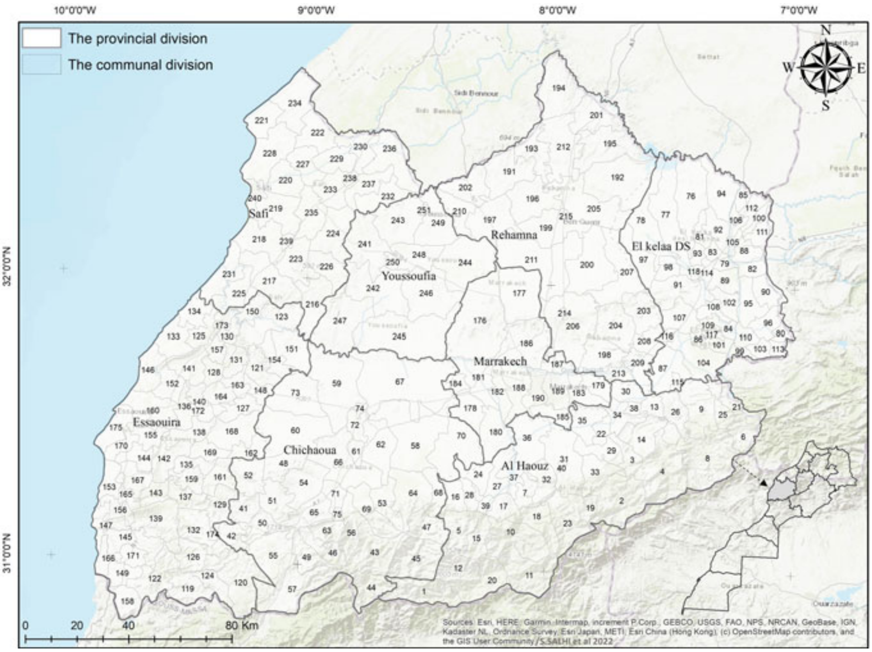

Fig. 2 Administrative division of the study area

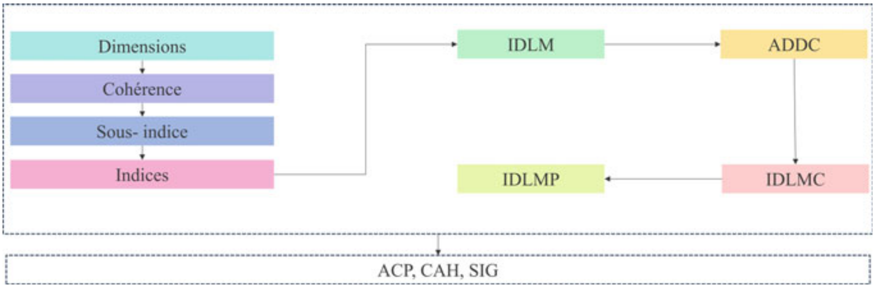

Fig. 3 Methodology adopted

Data Collection

The calculation of multidimensional territorial development index (MTDI) is based on the data of the general census of population and housing in Morocco of 2014, and on the approach of the choice of indicators, adopted by the United Nations Development Programme (2015) and National Observatory of Human Development (2017).

This approach is based on the choice of the main dimensions that together better express the level of development: the dimension of the level of education, the rate of economic activity, the state of health, the housing condition, the living environment and the distribution of social services. Subsequently, statistical tests of homogeneity of Cronbach's Alpha were applied to the indicators of each dimension.

Then, the dimensional index, (a dimensional index is the simple arithmetic average of the sub-indices of its elementary indicators), is created by calculating the sub-indices of each dimension (consisting of defining maximum and minimum values to convert all the indicators into indices between 0 and 1), giving the values of the development deficits.

Calculation of a Multidimensional Territorial Development Index

Based on the approach and results of National Observatory of Human Development (2017) in the calculation of development deficits, the creation of multidimensional territorial development index is established in three steps.

First, the average development deficit per municipality was calculated through the following equation.

$$\mathrm{ADDC} = \frac{\sum(\text{deficits})}{n(\text{number of deficits})} \tag{1}$$

Then, the multidimensional territorial development index at the communal level was calculated on the basis of the following equation.

$$\mathrm{MTDIC} = 1 - \mathrm{ADDC} \tag{2}$$

Finally, the multidimensional territorial development index at the provincial level is calculated from the following equation.

$$\mathrm{MTDIP} = \frac{\sum(\mathrm{MTDIC} \times \text{population})}{\sum \text{populations}} \tag{3}$$

Statistical Analysis PCA, HAC and Spatial Representation

For the statistical analysis of the results, Principal Component Analysis (PCA) and Hierarchical Ascending Classification (HAC) were used.

This method is used by Mo'oamin and Hamad (2015) for the determination of disparities in family living standards between Palestinian regions, and by AiMunandar and Winarko (2015) to analyse regional disparities in development in the region of Central Java in Indonesia.

For the spatial representation of the results, the geographic information system was used, to reveal the disparities existing in each geographical entity, this method is used by Iyanda et al. (2018) to detect sectoral and spatial disparities in maternal health indicators.

The Multidimensional Territorial Development Index at the Communal Level (MTDIC)

Spatial Distribution of MTDIC

The geographic information system GIS is a tool that allowed to visualize and analyse the spatial distribution of the information retained from calculations and analyses in order to create interactive queries (Pinol 2009).

In this study, after calculating the MTDIC, the results were exported to ArcGIS software in order to cartographically them in a figure to visualize the spatial distribution of multidimensional territorial development index at the communal level (Fig. 4).

The values obtained vary from 0.4 to 0.8, and the average value is 0.6, with a standard deviation of 0.09. The lowest value is recorded in the commune of Bouabout Amdlane (Ref: 41) in the province of Chichaoua and the commune of Ait Aissi Ihahane in the province of Essaouira (Ref: 119) with a value of 0.4, these communes are located in a poor rural environment, characterized by medium altitudes with a lack of water resources and a great weakness in road accessibility.

The highest positive value is recorded in the commune of Marrakech (Ref: 189) with a value that reaches 0.8, located in a plain, with favourable hydrological characteristics (characterized by the presence of an important water table and an accessibility of the transport networks), so it represents the only economic activity centre of the prefecture.

Variation and Disparity of MTDIC at the Level of Each Province

The analysis of the multidimensional territorial development index at the communal level in each province (Fig. 5) coincides with those found in the cartographic presentation of the results, the prefecture of Marrakech recorded the highest average of MTDIC (0.69), with a maximum of 0.80 and a minimum of 0.57, because its capital

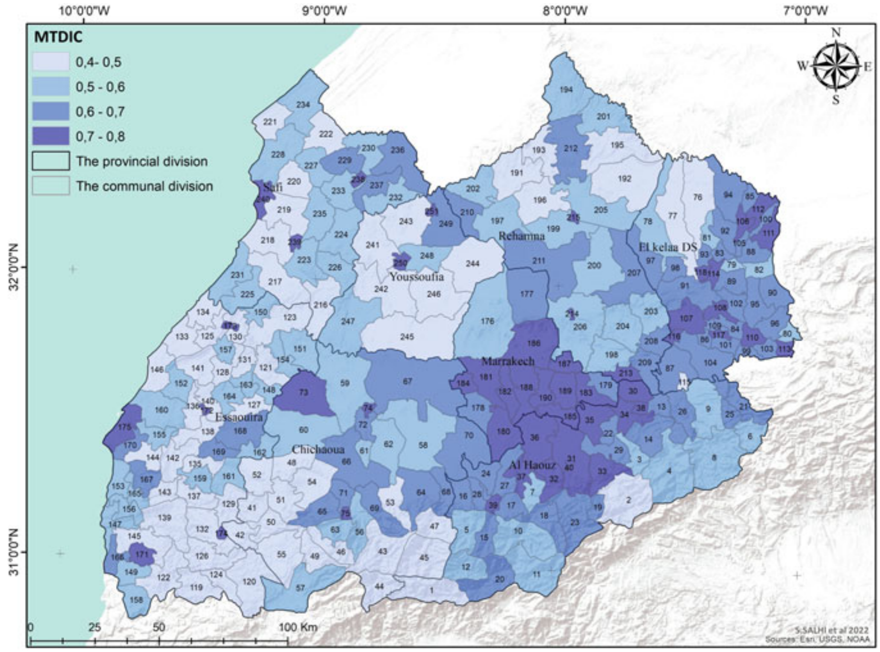

Fig. 4 Multidimensional territorial development index at the communal level

is the commune of Marrakech (also the seat of the Region), it is one of the richest communes in Morocco, and it fulfils several regional functions. It is the seat of regional institutions and organizations, the University, the regional administrative capital, the sub-regional and prefectural capital, an important industrial centre, the seat of banks, the presence of an international airport and a busy train station, a commercial and service centre of the first order in the region, also it knows a concentration of development projects, namely 29 projects between the projects programmed under the national and sectoral strategies (NSS) and the regional development plan (RDP), according to the regional monograph of the region of Marrakech-Safi in 2018. Also, the prefecture of Marrakech alone concentrates nearly 51% of the urban population of the region, with 9.7% of the rural population vulnerable and a poverty rate of 1.8% (the lowest percentages compared to other provinces in the region).

Essaouira province had the lowest average MTDIC Essaouira province also had the greatest variation in MTDIC with a maximum of 0.79 and a minimum of 0.44.

The province with the greatest disparity in MTDIC is the province of Youssoufia (0.1), characterized by economic disparities between the centre and the periphery, a geographic concentration of wealth and poverty, as well as several constraints in this heterogeneous area, including vulnerability, school wastage, and a water deficit in several of the province's territorial communes. However, the province with the

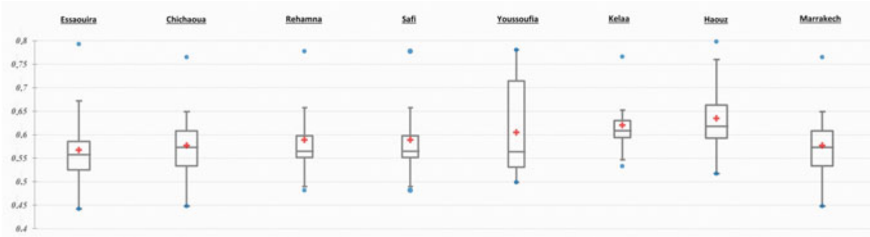

Fig. 5 Variation in MTDIC at the provincial level

lowest MTDIC disparity is the province of El Kelaa des Sraghna (0.05), which is a homogeneous territory (Fig. 6).

The provinces of Essaouira and Youssoufia each have 13% of the rural population and only 5% of the urban population of the region, so these two provinces are among the areas that fall within the "triangle of poverty", namely Essaouira-AL Haouz-Youssoufia. This triangle alone accounts for more than seven out of ten of the region's rural poor (71.6%).

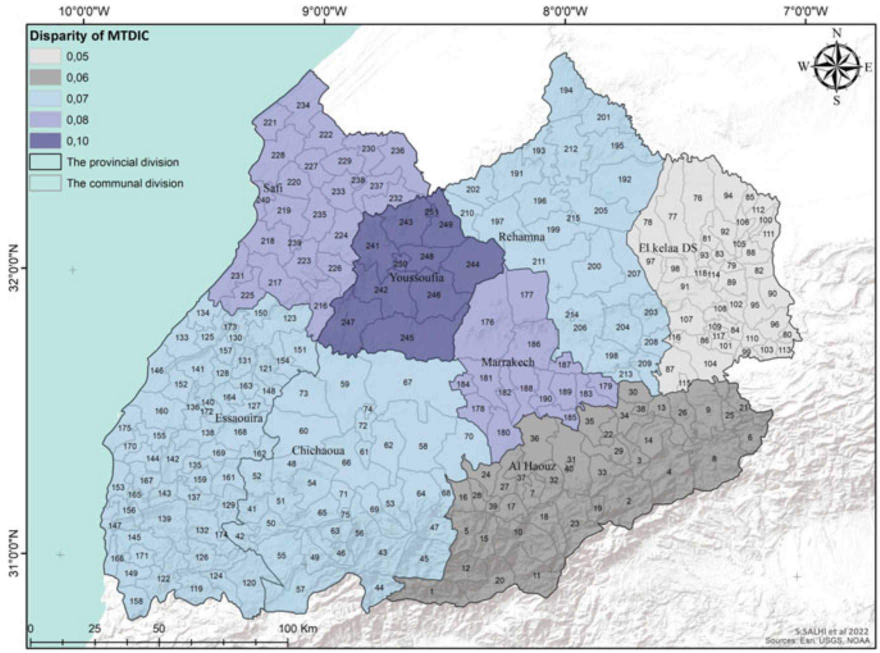

Fig. 6 MTDIC disparity at the provincial level

The Multidimensional Territorial Development Index at the Provincial Level (MTDIP)

After calculating the multidimensional territorial development index at the provincial level, the results were represented in Fig. 7.

The calculation of MTDIP for each province showed a minimum of 0.60, maximum of 0.75, average of 0.65 and a standard deviation of 0.05, the lowest average 0.60, is recorded at the level of Essaouira Province, while the highest 0.75 is recorded at the level of Marrakech Province.

In the case of the province of Essaouira, we can say that the phenomenon of "hidden areas" has negatively impacted the entire province, unlike the prefecture of Marrakech this phenomenon has played positively in favour of the prefecture. Indeed, the province of Essaouira, despite its size, its resources and its strategic geographical position, it has 52 rural municipalities (undeveloped) out of a total of 57, so the low MTDIC of the 52 rural municipalities has negatively impacted the average by revealing the existing disparities and hiding the reality that the municipality of Essaouira is developed. However, in the case of Marrakech with its 15 communes, the high MTDIC of the city of Marrakech has positively impacted the average by hiding the existing disparities at the level of the entire prefecture.

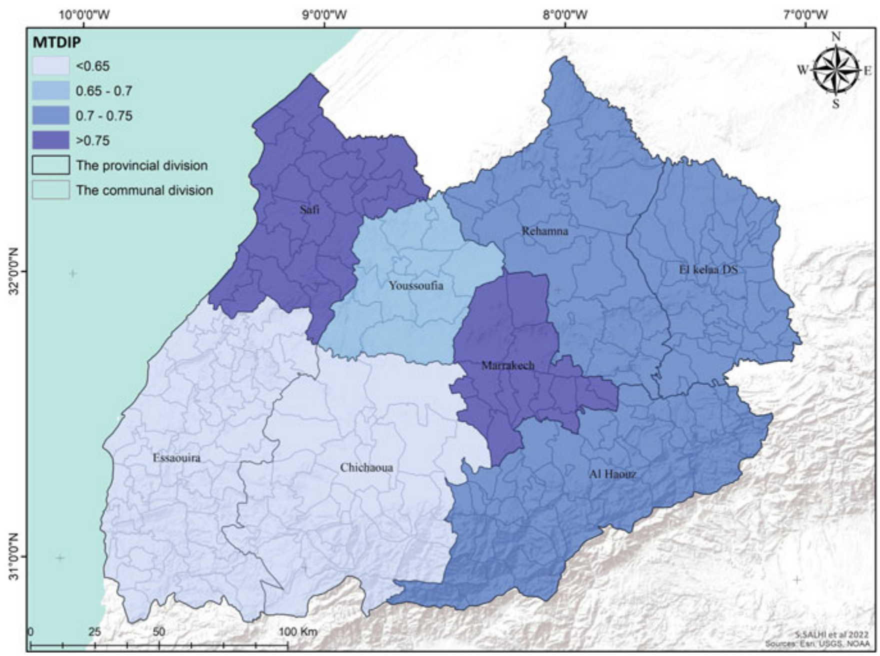

Fig. 7 Spatial distribution of the multidimensional territorial development index at the provincial level

Table 1 Correlation table of deficits used for the calculation of MTDI

	Education	Health	Economic activity	Habitat	Social services	Level of living
Education	1	0.45	0.31	0.87	0.74	0.85
Health		1	0.03	0.43	0.33	0.34
Economic activity			1	0.36	0.30	0.39
Habitat				1	0.75	0.84
Social services					1	0.85
Level of living						1

What Correlation Between the Deficits Used for the Calculation of MTDI

Correlation Analysis Between Deficits

The result of the correlation analysis is presented in Table 1; the strongest correlation is observed between the housing and education deficit with a correlation factor of $r = 0.87$. The 5 deficits of education, housing, social services and standard of living are positively correlated with each other, which shows a causal relationship. The other deficits of health and economic activity show no relationship with any other deficit, which proves their independence from the others.

The Distribution of Deficits Used for the Calculation of MTDIC Within the 8 Provinces of the Marrakech-Safi Region

The application of PCA allowed us to understand the causal relationship between the deficits, and it also revealed gaps and significant inequalities, characterizing the spatial and social distribution of territorial development at the level of the communes of the region of Marrakech-Safi (Fig. 8), so the sum of the two axes $F1$ and $F2$ (80.27%) shows the reliability of this finding. At the level of variables, we have identified three groups. The first group is related to deficits in living standards, education, social services and housing. The second group is related to the health deficit, and the third group is related to the economic activity deficit.

Indeed, we can say that the disparities in the standard of living are due to inequalities in education, housing and social services, globally observed in the provinces of Essaouira, Chihaoua and Rehamna. However, the same cannot be said for the deficits

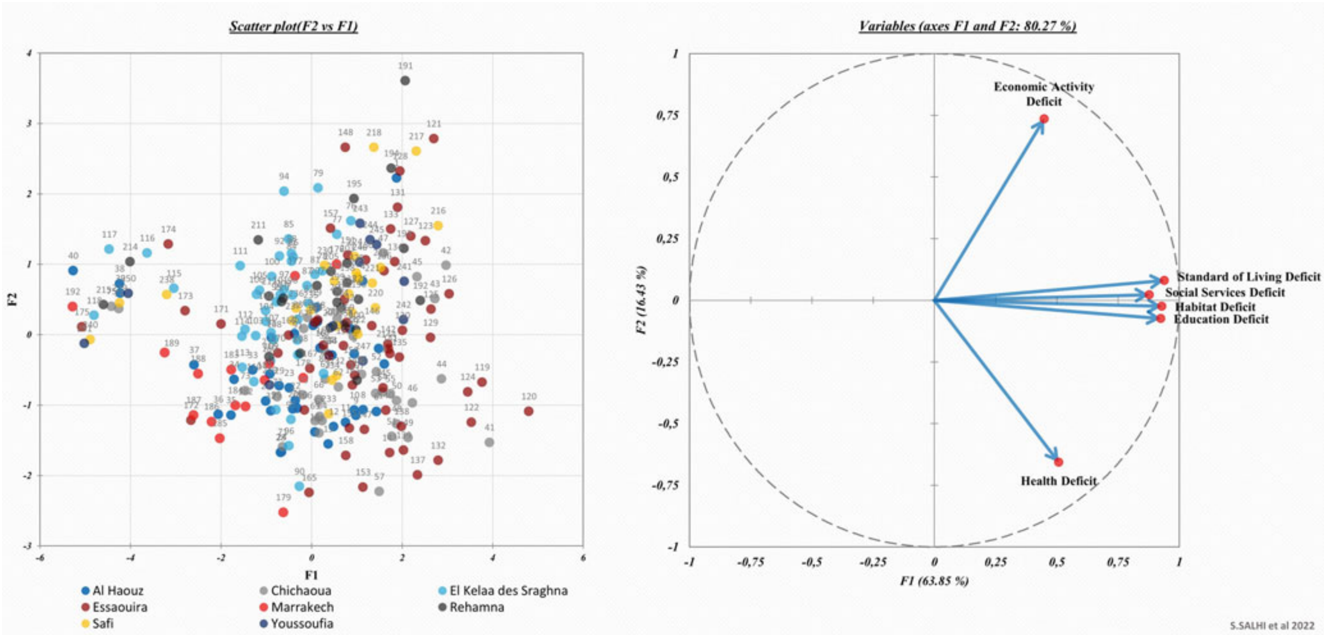

Fig. 8 The distribution of deficit values used for the calculation of MTDI by commune within the 8 provinces of the Marrakech-Safi region

in health and economic activity, which are independent. Due to the fact that the strong disparities in the economic deficit are observed in the provinces; Rahamna, Essaouira and El kala des sraghna and in the provinces; Chichaoua, Haouz and Essaouira in the health deficit.

Nevertheless, the scatter plot (Fig. 8) presented us with the situation of the municipalities of each province, in terms of spatial disparity. The communes of the province of Essaouira tend to the right (> 0) in relation to the F1 axis; these communes recorded the highest values of the deficits, especially with regard to the deficits of education, health, social services, housing and standard of living, the highest values of these deficits were recorded in communes of this province (0.67, 0.34, 0.57, respectively). The communes of the province of Chichaoua follow the trend of the communes of the province of Essaouira, in particular suffering from a large deficit in education, health and housing.

These deficits explain the low MTDIC value of the two provinces that we have presented above and detailed below in the discussion.

The communes of Al Haouz province tend to the left of the scatter plot (< 0 in the $F1$ axis), the communes of this province record low rates of deficits, especially the deficits of economic activities, where the lowest average of economic activities was recorded (0.08).

The communes of the province of Youssoufia positioned in the centre of the scatter plot, with a slight shift upwards (> 0 in the $F2$ axis); this is explained by the fact that the communes of this province record low rates of health deficit.

The communes of the province of El Kelaa des sraghna, with a tendency to the centre, with a slight shift to the left (0 in the $F1$ axis); this is explained by the fact that these communes recording the lowest rates in the deficit of living standards, social services, education and housing, while they record the lowest rates of economic activities.

The communes of the province of Safi and Rehamna are located on the right at the top, (> 0 in the axis $F1$ and $F2$), and therefore, they record the lowest rates at the level of health deficits.

The communes of the prefecture of Marrakech are located on the left at the bottom (< 0 in the axis $F1$ and $F2$); the communes of this prefecture, therefore, records the lowest values of deficits in education, economic activity, housing, social services and standard of living, but on the other hand records high rates of health deficit. In short, the results show that the calculation of the average does not reflect the realities at the local level, so the phenomenon of hidden areas, as it can impact negatively the IDTM and it can also impact it positively, and this depends on the geographic monographic density of the province/(or region or national) study. Also, between the deficits there is a causal relationship, so that if we think about one deficit without thinking about the other, we will never be able to talk about a territorial development, because over time the untreated deficits will contribute to the production of others, which requires a territorial approach to development, and moreover, this will be the subject of our discussion.

A Causal Relationship Between the Deficits Used for the Calculation of MTDI and an Increased Disparity of MTDI at the Level of the Communes of the Marrakech-Safi Region

Our study indicates that whatever the level of the multidimensional territorial development index at the provincial or regional level, there is an existence of gaps and inequalities that persist at finer territorial scales such as the communes and the Douars-villages. Thus, several factors can be at the origin of these spatial disparities such as physical geography, accessibilities, distance from the industrialized centre and points of attraction and favourability. Nevertheless, this study makes it possible to present the territorial disparities characterizing the Marrakech-Safi region, through the representation of a cartography of development of the provinces and communes of the region, based on relevant and well-detailed statistical analyses, measured by the fundamental dimensions of development, namely education, economy, social services, standard of living and health as well as the territorial actors of development, giving life to its dimensions through projects of the territory.

Spatial Disparities in Relation to the Deficits Used for the Calculation of MTDI

According to our results, there is a strong existence of gaps and inequalities between deficits, translated into spatial disparity within the communes of the Marrakech-Safi region, the spaces where the disparity is high concern all the communes in a situation of economic deficit. For example, the lowest disparities (in relation to deficits) are observed in the communes of the province of El Kalaa des Sraghna, and the highest disparities are observed in the communes of the province of Youssoufia (Fig. 8).

Thus, spatial inequalities are not limited to deficits, but also involve the underdevelopment of geographically defined areas and the relative prosperity of these areas (Wasim and Munir 2017). Today, despite the adoption of advanced regionalization pushed by decentralization and deconcentration policies, as a means of revitalizing the local level, this spatial disparity (inherited from the colonial period) testifies to the lack of a that crosses top-down and bottom-up action of development projects at the local level. This spatial disparity (inherited from the colonial period) testifies to the lack of a cross between top-down and bottom-up action of development projects at the local level, because the local level cannot do everything and the same thing for the central level (the principle of subsidiarity) and of a multidimensional targeting of deficient territories, so that local development is above all the business of different autonomous actors who come together to manage the local thing (Teisserenc 1994; Leloup et al. 2005).

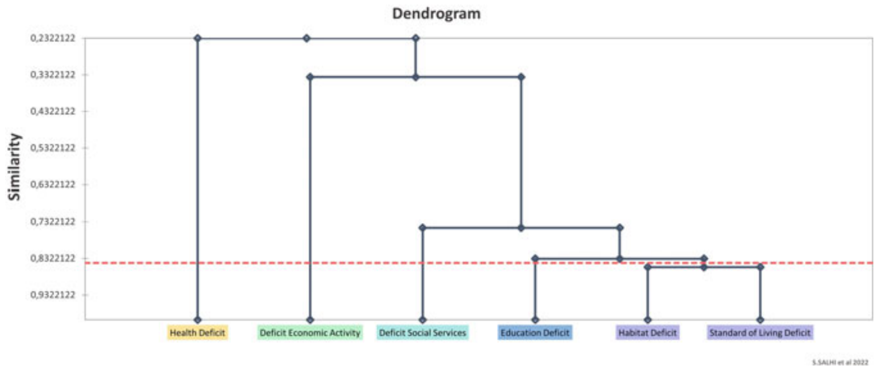

Fig. 9 Hierarchical bottom-up classification of deficits used for the calculation of MTDI

Links Between Deficits in Different Indicators

The ascending hierarchical classification is an analysis technique that allows to identify homogeneous groups, in our study (Fig. 9), and this technique has revealed deficits in housing and in the "standard of living" that are very similar and related to each other. In addition, if there are better housing conditions, there will automatically be an improvement in the standard of living, and vice versa. The latter are linked to the lack of education, so that if households are better off (living in villas or houses, having a toilet, water, electricity, television, satellite dish, fixed and mobile telephone), if they live in urban areas (the distance to the paved road is less than one kilometre), if they are educated (population knowing Arabic and French, having the level of secondary school or higher), then they will have a good standard of living.

These findings assert that poor socioeconomic conditions is at the root of educational inequalities (Shavit and Blossfeld 1993; Meuret and Morlaix 2006; Mingat 2007; Lanus 2009; Alexiu et al. 2010; Pillay 2017). Thus, the greater the distance between school and residence, the greater the likelihood of leaving school (Ibourk and Amaghouss 2016).

Disparities in MTDI in the Communes of the Marrakech-Safi Region

The calculation of multidimensional territorial development index at the provincial level (MTDIP) allowed us to classify the provinces of the region of Marrakech-Safi in three categories: developed; in development; and underdeveloped; therefore, going down to a lower level (the commune), we proceeded to the calculation of the multidimensional territorial development index at the commune level (MTDIC), which showed the heterogeneity and the inequalities characterizing the territorial and social distribution of the territorial development at the commune level within the same province, whether it is generally classified as being in development or developed. Certainly, a developed region does not reflect the realities of its provinces and communes (Jacka et al. 2013). Thus, in order to achieve a balanced regional or provincial structure, local actors must take into consideration the specificities and deficits of each territory (Ibourk and Amaghouss 2016). The solution to the problems of inequality of development that any territory knows resides in the efficiency and capacity to create and realize projects of the territory to make them real levers of development. For this, it is necessary that the actors of the territory work together to meet the individual and collective needs of the local populations, within the limits of the legal competences and the financial means at their disposal. Because the problem lies not only in the choice of more or less important projects, but also in the creation of a synergy between the territorial potential and its human resources (actors), thus ensuring a local development in harmony with the regional and national orientations, in terms of spatial planning acting a posteriori to correct these socio-spatial inequalities (ElAnsari 2008).

The observation of current spatial disparities in the world shows that they do not only distinguish between the developed countries of the North and the emerging countries of the South, but also apply to different scales of the same region.

As a result, the Marrakech-Safi region has strong disparities, creating great contrasts between rural and urban areas, and between the region's capital (Marrakech) and the other communes. From this perspective, the use of this method, as a preliminary diagnostic study, could be mobilized before the elaboration of any urban planning document or action plan, because development cannot be seen from a much higher and global scale (Region), whereas a finer geographical targeting such as that of the commune or even that of the Douar-village would lead to more effective decisions and greater efficiency of public policies aimed at the production of collective goods. These achievements can contribute, on both sides, to the reduction of inequalities; the creation of new employment and income opportunities, particularly within the degraded territorial communities, especially from the point of view of educational development and reduction of the exodus of the young population.

In the sense that territorial specificities remain the distinguishing element of policy action, the literature on spatial disparity is mainly based on traditional measures of inequality and focuses on its geographical decomposition (Azzoni 2001; Nissan and Carter 2006; Beenstock and Felsenstein 2007), as well as on multiple socioeconomic indicators (Quadrado et al. 2001).

In the case of Morocco, although there are few scientific studies devoted to the issue of spatial and regional disparities, it is still very present in the public debate and political discourse related to regionalization and devolution. Nevertheless, the last decade has seen an increase in the number of institutional reports dealing with the different dimensions of regional disparities in Morocco, such as the report on advanced regionalization prepared by the Royal Advisory Commission on Regionalization (RACR), and the report of the High Commission for Planning, which analyses socioeconomic indicators at the regional level. Also we find the works of (Altinok 2006; ElAnsari 2009; Ibourk and Amaghouss 2012, 2013, 2016; Mourji and Abbaia 2013), dealing with spatial disparities in several sectors and regions of Morocco.

However, our results confirm and complement those of the only works on spatial disparities in Morocco, and these results have led us to reveal and scientifically prove other realities related to spatial disparities, such as the place of geographical and climatic factors, as well as the relationship of independence and causality that exists between the different deficits. Also, these results led us to reveal and scientifically prove other realities related to spatial disparities, such as the place of geographical and climatic factors, as well as the relationship of independence and causality that exists between the different deficits. Furthermore, these results allow us to understand the challenges of development, providing a reference point for the management and exploitation of resources and the development of territorial policies that respond to the realities of each territory.

Conclusion

The results of our statistical analyses provide numerous findings that provide insight into the spatial distribution, relationships and spatial disparities of deficits at the local level, indicating that there is a significant relationship between the standard of living deficit and other deficits related to education, housing, and social services. Moreover, if households are better off in terms of housing, live in more accessible urban areas, and benefit from schooling, then they live in confirmed well-being. However, the deficit in education conditions the deficit in social services and welfare. Nevertheless, the results encourage a generalized study in various regions of Morocco on the basis of development gaps at the communal and provincial levels and why not by Douar-village.

After proposing an analytical framework for a territorial approach to spatial disparity, the objective was to emphasize the need to take into account the lowest level of community (the commune) in the process of catching up on regional inequality, since the reduction of regional disparities requires a communal focus. The commune is considered the basic territorial authority and the foundation of decentralization, constituting the pillar of territorial development in Morocco, since it develops its territory by implementing development projects in relation to its territorial potential and resources. Our approach, based on cartography and principal component analysis, constitutes in this field adequate tools to detect areas suffering from spatial disparities. But it is still necessary to work more on the reasons, the persons responsible of these disparities and the adequate solutions to overcome them, also to supplement this study the state of the index of the well-being by commune deserves to be studied, because in the end any strategy and policy of development has as finality the well-being of the citizens.

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SDG 11. Make Cities and Human Settlements Inclusive, Safe, Resilient, and Sustainable

Sustainable Cities, Urban Indicators and Planning for the New Urban Agenda. Sustainable Developments Goals and the Rights to the City

Rafael De Miguel González and Marta Lora-Tamayo Vallvé

Abstract Sustainable Development Goal number 11—Sustainable Cities and Communities—and New Urban Agenda promote a new framework for sustainable urbanization worldwide. Both institutional documents define strategies, frameworks and guidelines, for sustainable urban and regional planning, but also for urban management, so targets and indicators are a key issue to monitor how cities are achieving this particular eleventh sustainable development goal. This chapter will analyse firstly the impact of these new frameworks on master plans, as they are introducing several indicators about sustainable urban development, in addition to traditional urban planning based on regulatory standards: property rights, land use, zoning or built environment and population density indicators. Secondly, from UN-Habitat references to European Union urban policy to Spanish urban planning, it will analyse indicators expressed at SGD 11 or New Urban Agenda, but also indicators proposed by other European and national bodies for urban planning laws or urban management guidelines. Last, a definition of urban rights will be provided to open the discussion about improvement of indicators for sustainable urban development and achievement of urban (and human) rights.

Keywords New Urban Agenda · Sustainable cities · Indicators · City planning · Urban rights

Introduction

The Sustainable Development Goals (SDGs) were set up in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030. They have been designed to be a blueprint to achieve a better and more sustainable future for

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_11

all. Among the 17 SGDs, the eleventh goal is called Sustainable Cities and Communities. For the first time ever, sustainable urban development was placed in the centre of the international Agenda of United Nations from a people-centred, universal and transformative approach, integrating the three dimensions of sustainable development—economic, social and environmental—as a plan of action for people, planet and prosperity.

Previous United Nations Declaration, Millennium Development Goals (2000–2015) defined Goal 7 (Ensure environmental sustainability), in which Targets 7C and 7D called for increasing the proportion of urban population with sustainable access to safe drinking water and basic sanitation and reducing the proportion of urban population living in slums. So, urban issues have been promoted from the rank of Target to Goal. Thus, SDG 11 is a holistic and more inclusive approach on urban challenges worldwide, with a higher degree of engagement, equity, universality and scope than Millennium Development Goals, as expressed in the ten targets comprising SDG 11 itself (Table 1).

Table 1 Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities
11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels
11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

Source United Nation's Agenda 2030

Table 2 Principles and commitments for sustainable urban development at the New Urban Agenda

Principles for sustainable urban development	Transformative commitments for sustainable urban development
Leave no one behind, by ending poverty in all its forms and dimensions, including the eradication of extreme poverty	Sustainable urban development for social inclusion and ending poverty
Ensure sustainable and inclusive urban economies, including high productivity, competitiveness and innovation, by promoting full and productive employment and decent work for all	Sustainable and inclusive urban prosperity and opportunities for all
Ensure environmental sustainability by promoting clean energy and sustainable use of land and resources in urban development	Environmentally sustainable and resilient urban development

Source New Urban Agenda

The New Urban Agenda, adopted at Habitat III, 2016, presents a paradigm shift based on the science of cities and lays out standards and principles for the planning, construction, development, management and improvement of urban areas. The New Urban Agenda is intended as a resource for different actors in multiple levels of government and for civil society organizations, the private sector and all who reside in urban spaces of the world. The New Urban Agenda highlights linkages between sustainable urbanization and job creation, livelihood opportunities and improved quality of life, and it insists on incorporation of all these sectors in every urban development or renewal policy and strategy. Unlike the two previous Conferences in Vancouver (Habitat I, 1976) and Istanbul (Habitat II, 1996), the one in Quito expressly cites the role of control over urban growth and the physical shape of the city as an essential factor in achieving sustainable urban settlements. Habitat III addresses three principles for sustainable urban development corresponding to social, economic and environmental dimensions of cities and communities, interlinked to three transformative commitments for sustainable urban development (Table 2).

Thus, the New Urban Agenda works as an accelerator of the Sustainable Development Goals (SDGs), particularly SDG 11 to provide a comprehensive framework to guide and track urbanization around the globe. But reaching this, universal commitment to sustainable urban development has not been easy or obvious. It has taken twenty-four years, since the Earth Summit in Rio de Janeiro in 1992 that defined the concept of sustainable development (or thirty years if the reference of the 1987 Brutland Report is taken into account) to apply the principles of sustainability to urban development in four dimensions: *academic, urban planning practice, urban law and urban management*. Months before Rio Summit, highly cited references about European suburban development expressed the verification of a never-ending urban growth in the context of the economic revival in the late 1980s (Hall 1992). Thus, urban development was the better expression of economic growth and social development at those times, and it was considered—particularly suburban development—as an irreversible and deep process (Steinberg 1991).

Conversely, after Rio Summit prominent urban geography and urban planning scholars (Breheny 1992; Calthorpe 1993; Rydin 1995; Jenks et al. 1996) begun to define theoretical frameworks for sustainable development in the urban and metropolitan scale, thus thinking bigger and comprehensively than merely eco-urbanism for individual new sustainable neighbourhood units, even shifting the epistemological basis of urban planning paradigms (De Miguel 2004). In this way, containment, sustainable urban form, affordable housing, bioclimatic architecture, greenhouse emissions and impact on climate change, nature-based solutions, efficient urban basic services, sustainable transportation, environmental assessment, etc., have raised as essential references for a wider and subsequent literature, and for any urban policy, at any city and metropolitan area in the five continents, no matter the size, location or regional wealth.

Urban Planning Monitoring Sustainable Cities and Communities

In the traditional system of planning before 1992, urban and regional planning documents used to determine quantitative thresholds for expansive urban growth in terms of population growth, numbers of houses to be built, extension of the urban sprawl or number of strategic development areas like new towns or development zones (De Miguel 1999). For example, *Regional Plan of New York* (1929) and its environments expressed a goal of 30 millions of inhabitants for the long term. *Greater London Plan* (1944) proposed housing for 1,033,000 inhabitants due to reconstruction and new urban developments, despite urban containment and green belt were introduced in the proposal of Avercrombie. *Plan General de Ordenación del Área Metropolitana de Madrid* (1963) foresaw almost 3000 ha for the new urban growth. *Schéma directeur d'aménagement et d'urbanisme de la Region de Paris* (1965) indicated that 100,000 new housing units per years should be built in the 12 years after the plan approval, and this is 1.2 million in total, thus duplicating the number of existing houses in 1965. *Plan Director del Area Metropolitana de Barcelona* (1968) estimated new towns around 200,000 inhabitants, extended with an average urban growth of one hundred gross squared metres per habitant.

Subsequent urban planning in the 1970s and 1980s maintained this same intention for the main indicators in planning documents as a numerical reference and guide for constant growth, this is, as conventional land-use planning in the greatest sustained period of growth for the Western economies since the industrial revolution, what did imply the explosive urban growth in the decades after the World War II. But what actually happened was that the oil crises of the 1970s and the economic recession in the 1980s had a serious impact on urban deindustrialization and even a demographic decrease in European cities. Hall (1988) affirms in the chapter “the city of enterprise, planning turning upside down” that in that period “planning turned from regulating urban growth, to encouraging it by any and every possible means… as cities were machines for wealth creation”.

Thus, any urban initiative linked to limits to growth (in reference to the initial report of the Club of Rome) was doomed to failure because in this context the only important thing was to leave behind the crisis, so until the mid-1990s sustainable development concepts and instruments were not included into regional plans and master plans. Since then, sustainable urban development has been the new paradigm in urban planning, but in a more theoretical way than empirical. It is essential to highlight that sustainable development concept was introduced in national regulatory frameworks of planning law in European countries in the new century (Lora-Tamayo 2017), and particularly in:

- France: after 2000 (*Loi 2000–1208, relative à la solidarité et au renouvellement urbains*), a project for sustainable development planning is compulsory in master plan (SCOT) and local plans (PLU) called *projet d'aménagement et de développement durable*
- United Kingdom: Planning and Compulsory Purchase Act 2004 introduced Planning Policy Statements like PPS 1 (Delivering Sustainable Development) or PPS12 (Local Development Frameworks), later replaced by National Planning Policy Framework.
- Spain: urban law of 2007, later replaced by urban law of 2015.

Another important inputs are master plans. First big plan to be approved after Rio Summit was in Paris Region (*Schéma Directeur Région Ile de France*, 1994), which designed measures for the containment of urban sprawl, sustainable transportation and environmental assessment, as well as its updated version or other master plans in European cities like London, Berlin, Rome or Barcelona (De Miguel and Ezquiaga 2012). However, environmental assessment is insufficient for achieving urban sustainable development comprehensively, but also to obtain empirical evidences of the sustainable evolution of the cities and communities involved by the master plan. These and another master plans usually do not deploy urban indicators for monitoring sustainable cities and communities from urban planning. Most of the times, the fact that master plans are regulatory documents for urban growth and urban form makes difficult to include other important elements of sustainable urban development as social inclusion, participation, transition to a digital economy, management of basic urban services, energy supply or climate change mitigation.

On the contrary, The London Plan (2004) was the first and only one which included a series of indictors for monitoring London Plan from a wider approach. Its updated version of 2011, and specially, the last one presented in 2021 (Fig. 1) called *The Spatial Development Strategy for Greater London*—this is few years later after SDG's and New Urban Agenda publication—gathers a set of Key Performance Indicators (KPIs) and measures to monitor the successful implementation of the Plan's policies. The measure for each indicator shows the direction and scale of change that The London Plan policies are seeking to achieve in terms of housing, economy, environment, transport, health, air quality, heritage and culture. Other regional plans like

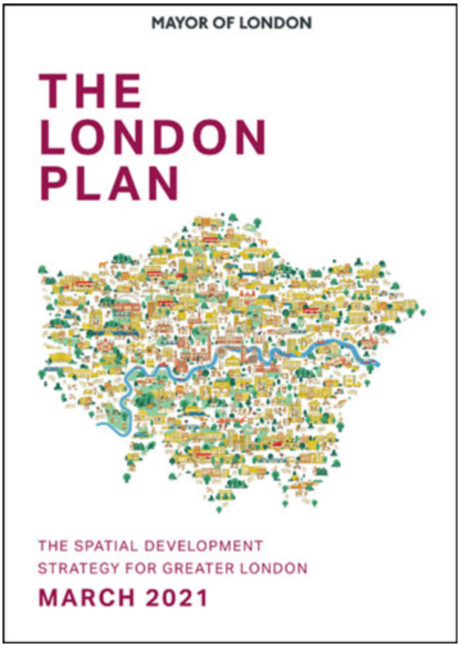

Fig. 1 The London Plan 2021. *Source* Greater London Authority

San Diego, Halifax or Sidney have also introduced indicators for monitoring performance of the respective plans in terms of sustainability, thus opening an important debate about the role of regional plans and local plans to achieve sustainable cities and communities.

Urban Indicators for Sustainable Cities and Communities

United Nations Indicators

Nevertheless, planning elaboration and approval is a long and exhausting task, which does not include compulsory indicators in most of the European cities. Then, how to measure the evolution of the economic, social and environmental trends and the accomplishment of sustainability in cities and communities? Resolution of the General Assembly of the United Nations on 6 July 2017 has reaffirmed the one approved two years before for the presentation of 2030 Agenda and SDG's, but has adopted the global indicator framework for the Sustainable Development Goals disaggregated by several indicators particularly related to the respective seventeen goals and targets. For the SDG 11, one or two indicators extend the ten targets expressed in Table 1, so a total of fifteen indicators are described to monitor sustainable cities and communities goal as a wide diversity of the expression of urban sustainability, which concerns issues about housing, transportation, urban sprawl, local democracy, cultural and heritage, disasters, solid waste, greenhouse emissions, security, wealth (Table 3).

But from the very beginning, there is an important difference between the wishes expressed by the General Assembly and the actual availability of data that allow giving meaning to the indicators. At United Nations statistical website for SDG indicators (Fig. 2)—https://unstats.un.org/sdgs/indicators/database/—there are only five out of ten targets are comprised, but eight out of fifteen indicators. Beside this,

Table 3 Indicators for Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
11.3.1 Ratio of land consumption rate to population growth rate
11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)
11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters
11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities
11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months
11.a.1 Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city
11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
11.c.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials

Source United Nation's Agenda 2030

- GOAL 11 Make cities and human settlements inclusive, safe, resilient and sustainable
  - TARGET 11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums
    - INDICATOR 11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
  - TARGET 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losse
    - INDICATOR 11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
    - INDICATOR 11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attribu
  - TARGET 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and
    - INDICATOR 11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
    - INDICATOR 11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
  - TARGET 11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional
    - INDICATOR 11.a.1 Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) e
  - TARGET 11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans toward
    - INDICATOR 11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk
    - INDICATOR 11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Dis

Fig. 2 Indicators set by the UN Statistics Division for SDG11. *Source* United Nations

the disaggregation level of the data is by country or by regional grouping of countries, what makes impossible to discern the degree of urban sustainable development at the metropolitan level in order to implement comparative studies between one city and other one.

There is another option for visualization data in a dashboard and a map viewer provided by Sustainable Development Solutions Network (SDSN), to which EUROGEO is also partner. SDG 2021 report and data for the overall score and for each individual SDG can be found at https://dashboards.sdgindex.org/map. For SDG 11, there are also available data for four indicators from fifteen and also at the national level. To obtain data at city level, it exists another initiative from SDSN together with Esri called *SDGs Today*—https://sdgstoday.org—, which allows comparing daily data among different metropolitan areas in the world, but just in three indicators as air quality (Fig. 3). Same concern is expressed by European statistical agency or by national statistical offices. Eurostat is able to collect data for ten different sets of indicators, but most of them are not identical to SDG's indicators. For example, instead of indicator 11.6.1 (proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities), Eurostat publishes data for recycling rate of municipal waste in a national level of geographical entity. In Spain, INE (*Instituto Nacional de Estadística*) publishes nine of out of the fifteen indicators related to SDG 11, but just indicator 11.1 is disaggregated at regional level.

Because the lack of accurate and reliable data, comparable between cities and nations across the world, UN-Habitat has provided some other set of indicators to measure and monitor sustainable urban development. Contradictorily, the New Urban Agenda does not define any kind of indicators, and even the word indicator is not included in the long document. But New Urban Agenda highlights the importance of "high-quality, timely and reliable data disaggregated by income, sex, age, race, ethnicity, migration status, disability, geographic location and other characteristics relevant in national, subnational and local contexts" (Paragraph 157). In the next chapters, New Urban Agenda supports the role of data for effectively monitor progress achieved in the implementation of sustainable urban development policies and strategies (Paragraph 158), and particularly geographical data, mapping and

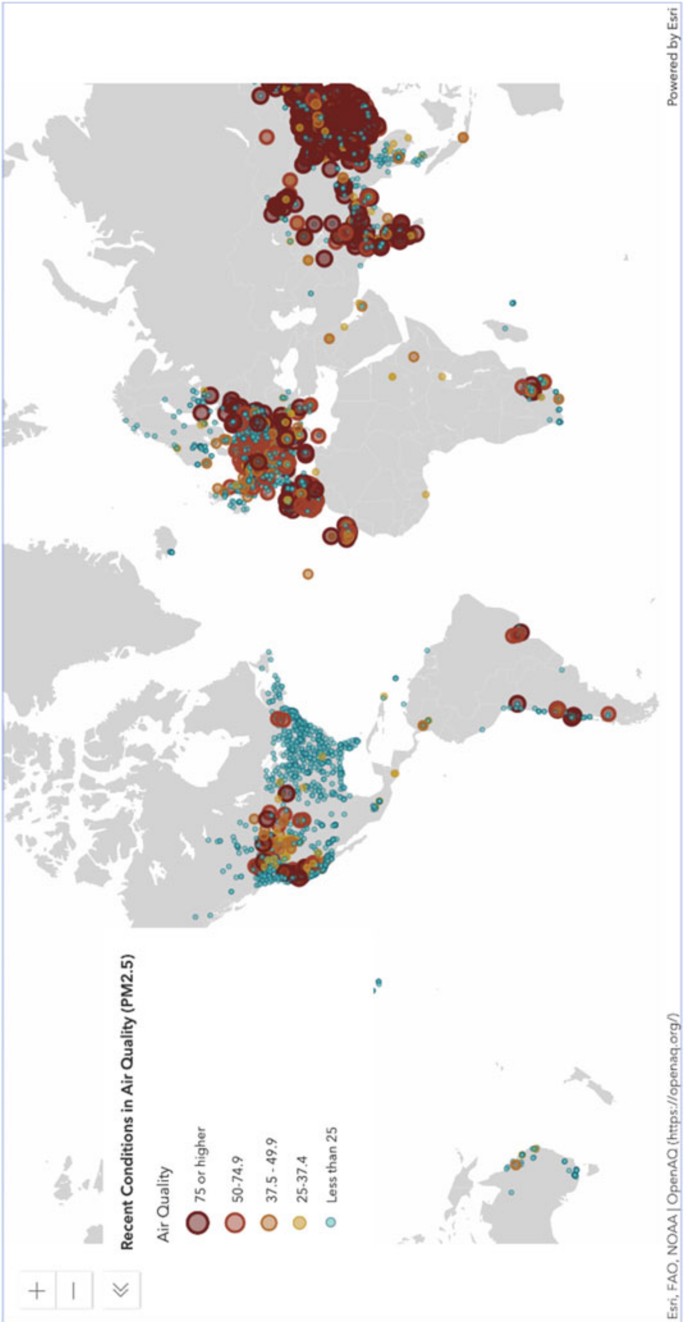

Fig. 3 Map of conditions in air quality at SDG's Today related to indicator 11.6.2. *Source* SDGs Today

participatory data platforms to promote evidence-based governance and to enhance effective urban planning and management (Paragraphs 159 and 160).

Apart from the three principles and commitments for sustainable urban development, the New Urban Agenda gives high importance to its effective implementation. So, the official text approved in Quito 2016, but especially the subsequent version for dissemination (UN-Habitat 2020), defines mapping and spatial data as a core dimension of the New Urban Agenda. In this extended document, indicators are quoted more than twenty-five times as essentials for effective implementation of the New Urban Agenda, but also as one of the four key elements supporting monitoring and reporting process. Thereby, front-line urban data and statistics compliment urban policy research and knowledge and support UN-Habitat in influencing the strategic policy engagements on sustainable urban development. Subsequently, UN-Habitat has developed the Monitoring Framework to track progress, assessing impact and assessing whether the New Urban Agenda's implementation is on track and well executed.

The New Urban Agenda recognizes the effective linkages and synergies between monitoring of itself and the 2030 Agenda for Sustainable Development to ensure coherence in their implementation (Paragraph 164). UN-Habitat estimates that nearly 40% of the SDGs family indicators are part of the core indicators proposed for of the New Urban Agenda Monitoring Framework. Hence, New Urban Agenda monitoring will contribute directly to SDG monitoring and vice versa. But New Urban Agenda Monitoring Framework is more complex than that, because it comprises twenty-five indicators from all SDG (not only from SDG 11), seven indicators from City Prosperity Index and forty-six indicators from UN-Habitat Urban Indicators Database, as they can be consulted at https://www.urbanagendaplatform.org/data_analytics.

City Prosperity Index has been created by UN-Habitat to measure the wealth and sustainability of cities in order to monitor policies and practices on sustainable urban development. It is a composite index based on six dimensions (productivity, infrastructure, quality of life, equity and social inclusion, environmental sustainability and governance and legislation) and over 15 sub-dimensions, well connected to the SDG 11 targets, but also to other SDG with urban-based targets (Fig. 4). At the same time, Global urban Indicators Database allows to define City Development Index, which is based on five indicators about City Product, Infrastructure, Waste, Health and Education.

Beside this, five post-Quito documents published by UN-Habitat also highlight the importance of urban indicators to monitor sustainable urban development. *UN-Habitat Strategic Plan* (2018) reaffirms the custodial role of UN-Habitat in defining and monitoring the urban indicators of the Sustainable Development Goals, and as a focal point for sustainable urbanization and human settlements, supporting the follow-up and review of the New Urban Agenda. *World Cities Report 2020* is supported by many statistics from UN-Habitat Urban (Global) Indicators Database. *Report of the Tenth Session of World Urban Forum* (2020) draw attention to the importance of data and knowledge as a fundamental starting point to understand gaps and needs and welcome the New Urban Agenda monitoring framework. Report entitled *Cities and Pandemics: Towards a More Just, Green and Healthy Future*

Fig. 4 Linkages between City Prosperity Index and Sustainable Development Goals targets. *Source* UN-HABITAT

(2021) suggests the creation of a global urban database on COVID-10 to monitor local impact of pandemic.

European Indicators

The European Union institutions have produced two key documents for the implementation of the New Urban Agenda in the member States. In 2016, few weeks before Quito Summit—but already published the final draft of the New Urban Agenda—the European Union Ministers responsible for Urban Matters agreed the Pact of Amsterdam for an *Urban Agenda for the European Union*. It included guidelines for monitor progress on the actions of the, but also quoted that “indicators and targets could be set”. Despite Urban Agenda for Europe doesn’t display a set of indicators, the twelve priority themes could be considered as the criteria for achieving a European sustainable urban development: inclusion of migrants and refugees, air quality, urban poverty, housing, circular economy, jobs and skills in the local economy, climate adaptation, energy transition, sustainable use of land and nature-based solutions, urban mobility, digital transition, innovative and responsible public procurement.

The Urban Agenda for Europe was based in the Leipzig Charter on sustainable European cities agreed in 2007, but updated in 2020 as *The New Leipzig Charter*. It defines the three dimensions of urban transformation, based on the integration of the social, ecological and economic dimensions of sustainable development: the just city, the productive city and the green city, which almost coincide with the three principles and commitments of the New Urban Agenda. Otherwise, this new version of the Leipzig Charter highlights digitalisation is a major transformative, cross-sectorial trend affecting all dimensions of sustainable urban development.

Apart from these two key references, there are many other proposals of indicators at the European level (European Commission 2018). Urban Audit provides European urban statistics for 258 cities across 27 European countries. It has been provided by the European Commission, in cooperation with Eurostat and the national statistical offices of the Member States and it contains more than two hundred of indicators for the following domains: Urban Audit contains data for over 250 indicators across the following domains: demography, social aspects, economic aspects, civic involvement, training and education, environment, travel and transport, information society, culture and recreation.

The European Handbook for SDG Voluntary Local Reviews offers to policy makers, researchers and practitioners an inspirational framework to set up Voluntary Local Reviews. The Handbook provides key examples of official and experimental indicators useful to set up an effective local monitoring system specifically targeted for European cities. Per each SDG, the Handbook highlights examples of harmonized and locally collected indicators. Particularly, for SDG 11 Handbook focuses on indicators about housing, transportation, green areas, air pollution and culture.

Last, European Reference Framework for Sustainable Cities is a toolkit to help European cities implement the sustainability goals of the Leipzig Charter on Sustainable European Cities. It has 5 dimensions and 30 objectives for a European vision of sustainable urban development. The tool has been tested in about one hundred European cities, as indicator set is extremely flexible depending on the needs and aims of any particular city, but also allows monitoring progress of urban policies.

Indicators in Spain

In Spain, the current law for land use and urban renewal (*Real Decreto Legislativo 7/2015, de 30 de octubre, por el que se aprueba el Texto Refundido de la Ley de Suelo y Rehabilitación Urbana*), was adopted some months before New Urban Agenda. So, there is no quotation to this international document, but a lot of references to sustainability. Apart from Article 3 (principles for sustainable urban and territorial development), there are some articles in the law that determine thresholds as indicators for sustainable cities and communities. For example, Article 20 requires a percentage of 30% of public housing in new urban developments by extension, but 10% in urban projects of renewal; or Article 24 promotes reduction of 30% of energy for heating and cooling buildings to reduce greenhouse emissions. Moreover, Article 22 defines environmental assessment report, a budget report for public investments, but also a monitoring report, published regularly, to track the evolution of environmental and financial sustainability of master plans. Final regulations of the law define a system of urban information -but not a system of indicators—for national and regional governments (*Disposición Adicional Primera*), and a threshold of sustainable urban development (20% of population growth or 20% of urban land extension from new development plans), which forces to review the general master plan regulating land use in the whole municipality (*Disposición Transitoria Cuarta*).

As the initial version of the current Spanish urban law was adopted in 2007—when principles for sustainable urban and territorial development were defined—from that moment several initiatives to fix indicators for monitoring urban sustainability intended to implement these principles. *Local Agenda 21* is an agreement between local governments, citizens and stakeholders to achieve local sustainable development from several indicators grouped in nine topics: pollution, mobility, water, waste, energy, biodiversity, climate change, participation and economy. The *Spanish Observatory for Sustainability* (OSE) has produced another important document in 2018 based on SDG's and the New Urban Agenda. It creates a ranking of the fifty-two capitals of province, which have been scored according to a weighted index calculated from fifty-nine indicators (economic, social, environmental, transparency). The results show that there are cities like Vitoria obtaining a score of 3729 and other like Ceuta almost half (2096), showing thus the spatial imbalances among Spanish cities in terms of sustainable urban development. A third initiative was launched by the Network of Networks for Sustainable Local Development that gathered 2800 local governments in which live more than 28 millions of inhabitants.

This network published a report in 2010 to establish a *local system for urban sustainability* based on twenty-seven indicators related to land use, public space, mobility, urban complexity, biodiversity, urban metabolism and social inclusion.

In 2010, Ministry of Housing published *White Paper for Sustainability in Spanish Urban Planning*, which assessed national and regional regulatory frameworks for urban planning from seven criteria of sustainability: natural environment, built environment, mobility, energy and resources, waste management, social inclusion and governance, each one comprising several specific criteria. Beside this, between 2015 and 2017, Spanish Ministry of Finances opened a public call for local governments to obtain European Regional Development Fund in order to enhance urban sustainability. In order to obtain these funds, cities had to prepare a *Strategy for Sustainable and Inclusive Urban Development* (EDUSI) focused in thirteen indicators from four main goals: Information and Communication Technologies towards the Smart City, Low Carbon Economy, Environment and Social Inclusion.

But just one law, three local initiatives, two national actions are not enough to obtain an updated approach of sustainable urban development in Spain, according the SDG's but particularly the New Urban Agenda or the Urban Agenda for the European Union. Consequently, Spanish Ministry of Housing presented in 2019 the *Spanish Urban Agenda.* It is a strategic document, without regulatory character, and therefore of voluntary adherence, which, in accordance with the criteria established by the 2030 Agenda, and the two aforementioned Urban Agendas (United Nations/UN-Habitat and the European Union), which seeks the achievement of sustainability in urban development policies. It also constitutes a working method and a process for all stakeholders, either public or private, who intervene in cities and who promote equitable, fair and sustainable development from their different fields of action. Spanish Urban Agenda is an integrated urban development framework offering a Decalogue of Strategic Objectives or Dimensions (Table 4 and Fig. 5) that unfold, in turn, a total of 30 specific objectives, and 291 lines of action, making available to those interested in its implementation, replicable to any Spanish city—doesn't matter size, population or urban features—, so that they can draw up their own action plans o Local Urban Agendas.

The set of monitoring and evaluation seventy-two indicators (thirty-five qualitative, thirty-seven quantitative) proposed in the Spanish Urban Agenda are associated with each of the specific objectives in which the strategic objectives of the agenda are developed. These indicators are adapted to the starting situation and the context of each of the cities and urban areas, but they are also compatible with the goals and indicators of the three international Agendas (Agenda 2030, New Urban Agenda and European Urban Agenda), but also with the other national and local initiatives aforementioned, particularly EDUSI, for which maximum compatibility and coordination with another similar indicators has been sought (De la Cruz 2019; Hernández and De Santiago 2019). They will make it possible to clearly define the results that will be achieved with the application of the Spanish Urban Agenda in terms of improving and monitoring the quality of life, but also sustainable urban development in Spanish cities.

Table 4 Indicators for Goal 11 related to European Union and Spanish Urban Agendas, to rights at New Urban Agenda and to main international indexes of sustainable urban development

Indicators SGD 11	City prosperity index (dimensions)	Urban Agenda for the European Union	European reference framework for sustainable cities (dimensions)	Spanish urban agenda (dimensions)	Urban rights at the new urban agenda
11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing	Productivity	Inclusion of migrants and refugees	Spatial	Regional planning and landscape	Housing
11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	Infrastructure development	Air quality	Governance	Urban sprawl control	Citizenship
11.3.1 Ratio of land consumption rate to population growth rate	Quality of life	Urban poverty	Social and cultural	Climate change	Ecological and social function of land
11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically	Equity and social inclusion	Housing	Economy	Circular economy	Ecosystemic vision

(continued)

Table 4 (continued)

Indicators SGD 11	City prosperity index (dimensions)	Urban Agenda for the European Union	European reference framework for sustainable cities (dimensions)	Spanish urban agenda (dimensions)	Urban rights at the new urban agenda
11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)	Environmental sustainability	Circular economy	Environment	Urban mobility	Urban economies
11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population	Urban governance and legislation	Jobs and skills in the local economy		Social inclusion	Planning

(continued)

Table 4 (continued)

Indicators SGD 11	City prosperity index (dimensions)	Urban Agenda for the European Union	European reference framework for sustainable cities (dimensions)	Spanish urban agenda (dimensions)	Urban rights at the new urban agenda
11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters		Climate adaptation (green infrastructure solutions)		Urban economy	Property
11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities		Energy transition		Housing	
11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)		Sustainable use of land and nature-based solutions		Digital age	
11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities		Urban mobility		Urban management	

(continued)

Table 4 (continued)

Indicators SGD 11	City prosperity index (dimensions)	Urban Agenda for the European Union	European reference framework for sustainable cities (dimensions)	Spanish urban agenda (dimensions)	Urban rights at the new urban agenda
11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months		Digital transition			
11.a.1 Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city		Innovative and responsible public procurement			
11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030					

(continued)

Table 4 (continued)

Indicators SGD 11	City prosperity index (dimensions)	Urban Agenda for the European Union	European reference framework for sustainable cities (dimensions)	Spanish urban agenda (dimensions)	Urban rights at the new urban agenda
11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies					
11.c.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials					

Source Own elaboration

OBJETIVOS ESTRATÉGICOS AUE	TOTAL Nº INDICADORES	Nº INDICADORES CUALITATIVOS	Nº INDICADORES CUANTITATIVOS	VINCULACIÓN ODS 11
1 ORDENAR EL TERRITORIO Y HACER UN USO RACIONAL DEL SUELO, CONSERVARLO Y PROTEGERLO	8	3	5	✔
2 EVITAR LA DISPERSIÓN URBANA Y REVITALIZAR LA CIUDAD EXISTENTE	17	6	11	✔
3 PREVENIR Y REDUCIR LOS IMPACTOS DEL CAMBIO CLIMÁTICO Y MEJORAR LA RESILIENCIA	6	3	3	✔
4 HACER UNA GESTIÓN SOSTENIBLE DE LOS RECURSOS Y FAVORECER LA ECONOMÍA CIRCULAR	8	4	4	✔
5 FAVORECER LA PROXIMIDAD Y LA MOVILIDAD SOSTENIBLE	6	2	4	✔
6 FOMENTAR LA COHESIÓN SOCIAL Y BUSCAR LA EQUIDAD	5	3	2	✔
7 IMPULSAR Y FAVORECER LA ECONOMÍA URBANA	4	2	2	✔
8 GARANTIZAR EL ACCESO A LA VIVIENDA	5	2	3	✔
9 LIDERAR Y FOMENTAR LA INNOVACIÓN DIGITAL	4	2	2	✔
10 MEJORAR LOS INSTRUMENTOS DE INTERVENCIÓN Y GOBERNANZA	9	8	1	✔
AGENDA URBANA ESPAÑOLA	**72**	**35**	**37**	✔

Fig. 5 Indicators for urban sustainable development goals at the Spanish Urban Agenda. *Source* Spanish Urban Agenda

Sustainable Urban Development and the Rights to the City

In previous sections, some key issues on urban policies, as well as indicators for sustainable urban development, are the basic challenges included in the Universal Declaration of Human Rights (1948), like mobility (Art. 13), property (Art. 17), social, economic and cultural rights (Art. 22), work (Art. 23), housing, well-being, health care (Art. 25), education (Art. 26) or culture (Art. 26). In fact, New Urban Agenda refers several times to human rights and particularly in paragraphs 11, 12 and 13, recognizing the “efforts of some national and local governments to right to the city, in their legislation, political declarations and charters” and aiming “to achieve cities and human settlements where all persons are able to enjoy equal rights and opportunities” because “the New Urban Agenda is grounded in the Universal Declaration of Human Rights”.

In order to assess if New Urban Agenda provide a stable legal framework for urban (and human) rights, including property rights and land use law, an implementation of the concentric circle theory has been provided (Lora-Tamayo 2020), from the right to the city (citizenship rights) to the right to urbanize (development rights) to the property rights (Fig. 6). The New Urban Agenda provides a wide variety of arguments and principles for sustainable urban development and for different stable legal frameworks related to planning and land use law, but it does not offer a clear structure about the way property rights are linked and interrelated.

The right to the city must be thought in an inclusive way, as a series of physical features, implicitly introducing the elements of the second concentric circle (right to urbanize). Paragraph 12 of the New Urban Agenda links the ideal of a city for all to the ideal of the city as a place where people can "enjoy equal rights and opportunities, as well as their fundamental freedoms, guided by the purposes and principles of the Charter of the United Nations including full respect for international law". In the third concentric circle, we could include a series of rights and duties linked from the physical and legal relationship of the human race with the city as place to complete inner cultural desires and aspirations under the broad umbrella of the right to the city. While it is true that the New Urban Agenda has the same principles in mind than Human Rights Declaration, it includes them in an unstructured way.

As per our previous work (Lora-Tamayo 2020), "The New Urban Agenda should have developed the concept of citizenship, persons as inhabitants of the city, as the Global Charter-Agenda for Human Rights in the City does. Although Paragraph 38 addresses cultural heritage and the need to strengthen social participation and the exercise of citizenship; this concept is not introduced in a full legal or political sense. The New Urban Agenda certainly affects the anthropocentrism of public policies focused on the city from the beginning, and the humanization of cities and settlements, but its implementation remains in a constructive plane in the dimension of housing, not urban as individual right".

Otherwise, the right to urbanize is not fully contemplated or defined in the New Urban Agenda, though it does propose measures to avoid speculation and appropriation of value by the private sector. Rather, it integrates a public sector duty to urbanize, as indicated in Paragraph 45 through commitment to develop "inclusive urban economies… fostering an enabling environment for businesses and innovation, as well as livelihoods". However, defence of the economic benefits of urbanization requires a certain right for private initiative, which is a missed opportunity that the New Urban Agenda could have deepened by addressing the challenges of public–private equilibrium in urbanization.

Last, the New Urban Agenda supports property rights, especially housing as a comprehensive indicator for monitoring sustainable urban development, and grants the right to benefit from urbanization. Nevertheless, property rights, and the social and ecological function of property rights are assumed vaguely, not explicitly.

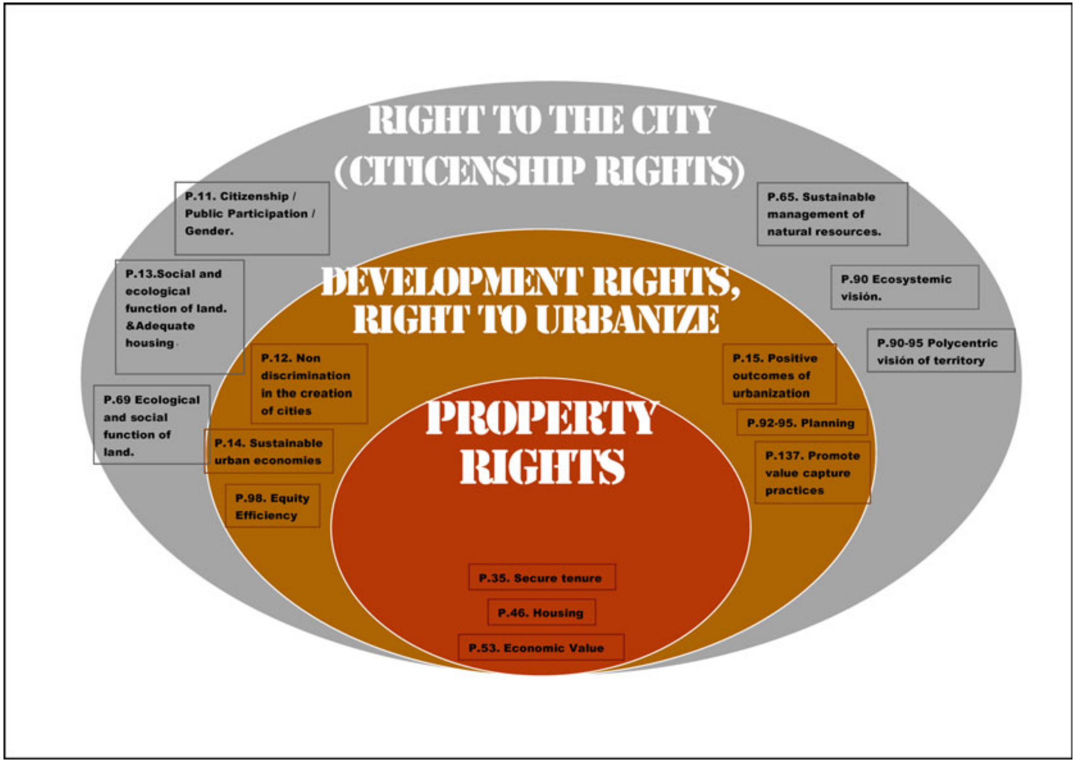

Fig. 6 Diagram of the New Urban Agenda analysed within the concentric circle theory. *Source* Lora-Tamayo, 2020 (own elaboration of the co-author)

Conclusions

Despite there are other papers to analyse indicators for measuring and urban sustainability and monitoring implementation of Agenda 2030 and New Urban Agenda (Jiménez et al. 2019; Gómez et al. 2018; Kitchin et al. 2015; Wong 2006; González and Lázaro 2005), this chapters seeks to approach this topic from the European perspective, where the degree of urbanization is different to other continents and where the awareness for urban rights and citizenship is very strong because of our particular way of life and consolidated democracy.

In the first place, it is evident that the New Urban Agenda itself, despite being one of the most important documents in history for the promotion of sustainable urban development—because of its length, because of the depth of the issues it deals with, but also because of the degree of political commitment—do not set indicators of achievement of objectives for monitoring the progress achieved. However, this lack of indicators of the New Urban Agenda itself is compensated with sectorial indexes such as the City Prosperity Index or with more complex indicator systems such as the New Urban Agenda Monitoring Framework. For their part, the SDG11 indicators, despite their indisputable interest, do not cover the thematic diversity of the New Urban Agenda, nor is there a total availability of data in all countries, nor do they allow a spatial analysis at the urban and metropolitan scale.

In this way, facing the obvious need for concrete, meaningful, but accurate and reliable urban indicators, not even UN-Habitat itself is capable of giving a satisfactory answer due to the enormous difficulty of monitoring and assessing urban sustainability, due to the balance that must exist between its political, economic, social, environmental and territorial dimensions, due to the enormous geographical, historical, cultural and urban diversity of cities in the world, or due to the degree of commitment of the local governments themselves: "however, we have not yet reached the finishing line; at present, we are undergoing a transitional process towards a fourth generation of more comprehensive and holistic sets of urban indicators in which several stakeholders are involved" (Gómez et al. 2018). The proof for this is that each institution—does not matter if UN-Habitat, the European Union or the Spanish government—is able to provide several sets of indicators at the same time, thus showing some uncertainty of their own conviction for a clear system for monitoring sustainable urban development.

The fact that in this chapter we have been able to present more than twenty different sets of indicators, most of them designed in recent years, demonstrates two things: the growing interest in having an accurate understanding of urban sustainability in order to continue improving and fine-tuning urban planning, urban policies, public actions and investments in cities, but also the difficulty of analysis due to the interdisciplinary and multisectoral approach of urban challenges. However, questions like Is it possible to replicate definition of sustainable urban development for one and each particular city? Is it possible to monitor through a set of indicators sustainable urban development for one and each particular city? Despite international, national and local particularities, both questions must have a positive answer in order to increase the knowledge and to foster good practices by urban policy makers and stakeholders.

Urban systems are complex but urban needs are simple as human needs: working, housing, moving, enjoying, respecting, personal growing, etc. United Nations remembers to us that an easy-to-calculate index like Human Development Index is an essential tool for tracking improvements in basic human rights, unless it does not take into account political issues. This is why indicators for sustainable urban development must be directly linked to urban rights (Table 4), in order to achieve urban prosperity, social inclusion, harmonious environment and exercise of citizenship.

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SDG 12. Ensure Sustainable Consumption and Production Patterns

Toward a New Sustainable Production and Responsible Consumer in the Food Sectors: Sustainable Aquaculture

María-Julia Bordonado Bermejo and Ana Lucía Ortega Larrea

Abstract The purpose of this chapter is to implement the Sustainable Development Goals (SDGs) in general, and specifically the SDG 12, in the production and consumption of a country. This research is based on the pyramidal economic structure developed by Jané Solá, which is correlated with the SDGs. As it is well kwon, the Sustainable Economic Development is an essential part of any sustainable development, where both production and consumption have to become equally sustainable. Therefore, this chapter reflects on sustainable production in aquaculture, the Spanish fisheries being one of the most important production sectors for the EU. Attention is also paid to the Strategic Projects for Economic Recovery and Transformation (the Spanish PARTE), as an effective resilience plan in the agricultural production sector. As for the sustainable consumption inherent in a Sustainable Economic Development, the conclusions of the study released by Deloitte are highlighted, in which the new characteristics of consumers and society are shown to demand a healthier and more sustainable production.

Keywords SDGs · SDG 12 · Sustainable economic development · Sustainable production · Sustainable consumption

Introduction

Economic policy is defined as government intervention in economic activity with the aim of achieving certain goals and objectives through the use of certain means or instruments (Economipedia 2022). However, in this simplified definition, concepts such as sustainable development or management policies are not evident. With the

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_12

aim of establishing a clear relationship among concepts such as Sustainable Development Goals and the production and consumption policies of a country reflected in the pyramid developed by Jané Solá, it is essential to explain these basic concepts and their relationship, namely economic policies, management policies, and sustainable development.

Economic policies refer to all political and associative activities, as well as to governmental measures aimed to regulate the economic process. The objectives of economic policy refer to social welfare and are also related to principles along with values of security and justice. Every economic policy is oriented toward certain objectives, uses certain instruments for its correct application, and ultimately, employs certain means of control to verify its compliance. In fact, the objectives are the reason for all economic policies, such as improving the standard of living and quality of life, reducing inequalities, pursuing social justice, and achieving **Sustainable Economic Development (SED)** that respects the environment. The instruments, for their part, help to achieve the previously selected objectives. Most of all, the means of control should make it possible to evaluate the effectiveness of economic policies. In brief, the economic policies should be oriented to attaining Sustainable Economic Development, which is an obvious part of the Sustainable Development Goals (SDGs) of the Agenda 2030.

Management policies tend to comply with the principles of Liberty, Equality, Justice and Interdependence in relation to the need for state intervention to guarantee the functioning of the free market. Thus, when we apply **management policies** to the economic policies, we come up with a new concept that we call "**Finalist Economic Policies**": a type of economic policy which tends to achieve objectives aimed at improving the economic and social situation. Among these objectives, we can highlight full employment, price stability, and even SDG 12, together with other Environmental Sustainable Development Goals. Indeed, the importance and the concern for obtaining economic growth with the due protection of the environment are also evidenced.

Sustainable development is, by definition, "the ability to satisfy human needs in the present without compromising the satisfaction of future needs; it is the possibility that human activity in the present does not exhaust natural resources to the point that it endangers human survival in the future" (Economipedia 2022).

It is, therefore, the search for solutions to the problems derived from industrialization and its repercussions without harming natural resources. The protection and care of the environment include the use of water-saving measures, investment in the use of renewable energies, as well as agricultural and fishing production with the reduction of impact on marine, terrestrial, and aerial environments. Therefore, it could be stated that by implementing the objectives of the Finalist Economic Policies, the way to achieve **Sustainable Economic Development** (SED) is being implemented.

Sustainable Economic Development

As far as the European Union is concerned, its Treaty on European Union (TEU) sets out that "*The Union is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities. These values are common to the Member States in a society characterized by pluralism, non-discrimination, tolerance, justice, solidarity, and equality between women and men*". Although this idea may be highly controversial, we cannot comment on economic policies in Spain without taking into account that we belong to the European Union, and as a Member State, we are affected by its economic and social principles. For this reason, basic principles of the European Union are being reviewed here (Fig. 1).

From the basic principles of the European Union, we obtain the basic principles of European Economic Policies. In fact, the application of any type of economic policy must be based on the principles of non-discrimination, political pluralism, justice, and equality between men and women.

The following Fig. 2 shows a pyramidal design, in which its apex consists of the basic principles of any Economic Management Policy, namely:

(1) Equality in the application of the rules.
(2) Freedom of market operation, from the point of view of supply and demand.
(3) Justice, which provides legal certainty in the exchange of goods and services in an economy.

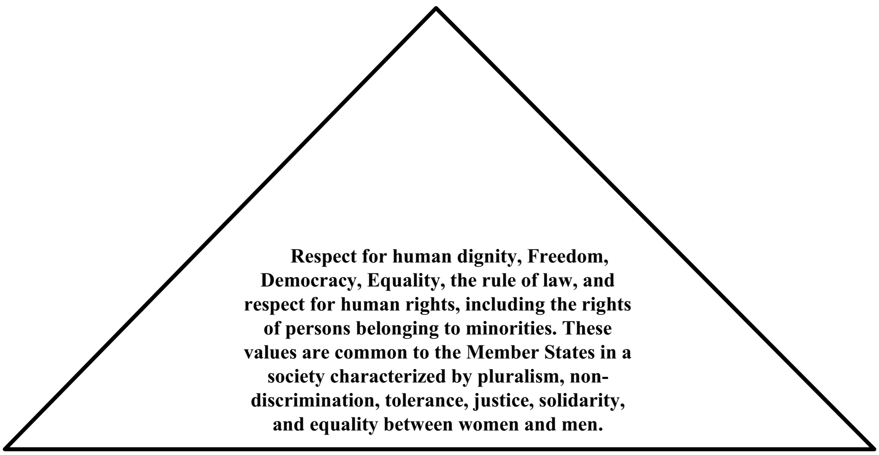

Fig. 1 Basic principles of the European Union. *Source* created by author

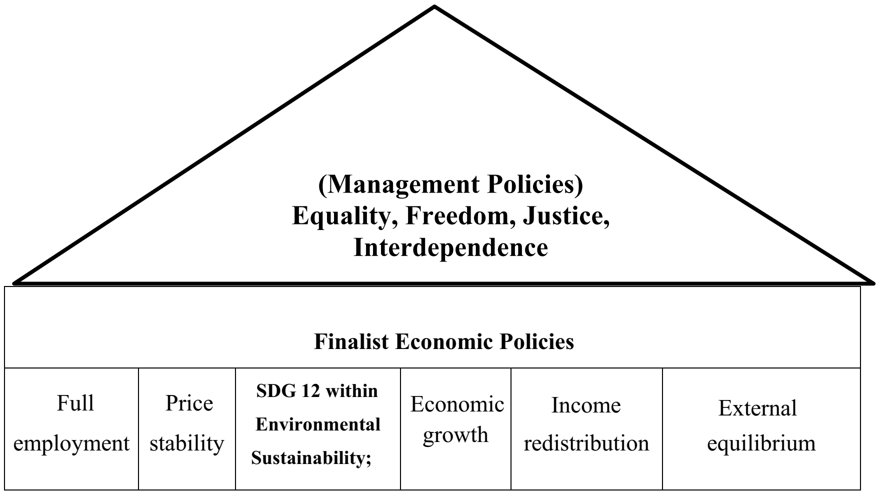

Fig. 2 Sustainable Economic Development (SED).[1] *Source* created by author

(4) Economic interdependence; a relationship of mutual dependence for the production of those goods and services needed by the consumers and users of a nation[2] (Algarra Paredes and Bordonado Bermejo 2009).

The rest of the figure represents the **Finalist Economic Policies** (Jordán 1995), that is to say, the policies that pursue certain objectives, such as full employment, price stability, economic growth, income redistribution, and external balance. For the purposes of this research, the Sustainable Development Goals are added, more specifically, Goal number 12 or "sustainable production and consumption", known by the acronym "SDG 12".

Once the final scheme of **Sustainable Economic Development (SED)** has been determined, it is necessary to establish the differences between **sectoral and instrumental policies**, which, in the present research, are considered to be sustainable.

Therefore, the former, **Sustainable Sectoral Policies**, are policies applied to the development of each economic sector. A sectoral policy is a law or regulation of a specific ministry or department; for instance, the fisheries law, the water law, the environment law, the 2007 law for the sustainable development of the rural world, or the environmental assessment law, to mention a few sectoral policies related to the Sustainable Development Goal 12.

These sectoral policies interfere with **instrumental policies** in so far as they help us achieve the objectives set out in the **Finalist Economic Policies**. Instrumental

[1] United Nations Environment Programme. "Sustainability, https://www.unep.org/about-un-environment/sustainability". Accessed May 30, 2022.

[2] Algarra Paredes, A, y Bordonado Bermejo, MJ (2009) En el sesenta aniversario de la Declaración Universal de los *Derechos Humanos*: su relación con la política económica.

policies, such as fiscal, monetary, or labor policies, have a decisive influence on sectoral policies in order to achieve economic development as an indispensable part of the Sustainable Development Goals (SDGs). For this reason, Agenda 2030 tends to call these Finalist Economic Policies as "**Sustainable Instrumental Policies**".

Either way, **Sustainable Sectoral Policies** and **Sustainable Instrumental Policies** are interdependent as a means to successfully implement all the objectives of the **Finalist Economic Policies**. However, in practice, it is necessary to decide on only one of the **Finalist Economic Policies**' objectives because it is impossible to achieve all of them simultaneously. Therefore, in order to choose, for example, "SDG 12 within Environmental Sustainability", (UN Environment Programme 2022) the other objectives of the Finalist Economic Policies have to be momentarily put on hold (Fernández Diaz 1999).

The following Fig. 3 shows a pyramidal design with the inclusion of "Environmental Sustainability" within any country's economic policies.

Sustainable Economic Development (SED) implemented through the objectives of the Finalist Economic Policies requires both **sustainable production** and **sustainable consumption** (Ortega Larrea 2020).[3] In the following sections, we will outline some aspects of Spanish production in the aquaculture sector and the Strategic Projects for Economic Recovery and Transformation (PARTE), as an agri-food sustainable plan within the post-COVID-19 European context. Moreover, we will see that the new post-pandemic context has resulted in consumers and societies which are more aware of and concerned with sustainable production.

Sustainable Production

Sustainable Production: Aquaculture Sector

Sustainable production can be defined as a model of production of goods and services that minimizes the use of natural resources and the generation of toxic materials, waste, and polluting emissions by promoting a production management strategy that integrates the environmental dimension through a pollution-preventive approach and the efficient administration of these resources (Umass Lowell 2022).

We will now focus on sustainable production and, exemplarily, on the aquaculture sector. This economic sector includes the aquaculture of marine fish, freshwater fish, mollusks, crustaceans, algae, and echinoderms. For this reason, it includes the fish and shellfish sectors, and it is of exceptional importance in the Spanish economy, although it is scarcely addressed in comparison with the studies carried out on agricultural sectors. Due to its relevance in the Spanish economy, culture, and gastronomy, and because it has remained largely unexplored in our country, it has been chosen for this research.

[3] Ortega Larrea, Ana. (2020). "Una política de ética empresarial como fuente de valor. Efectividad de las políticas empresariales éticas". Ed. ESIC, Pozuelo de Alarcón, Madrid.

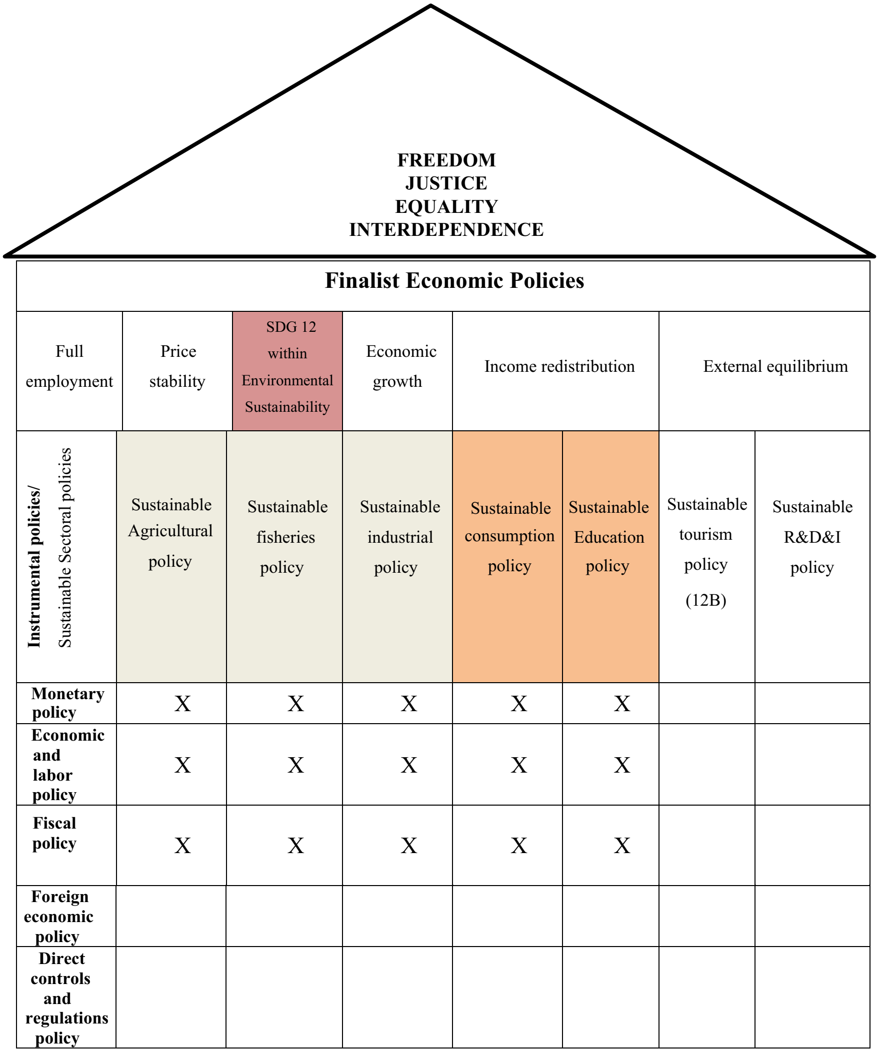

Fig. 3 Inclusion of sustainable development in a country's economic policies.[4] *Source* own preparation from Jané Solá, *NOTE TO EDITOR* Ser original chapter for this figure

The **aquaculture sector** is very important for its work demand factor, for its social and environmental repercussions that improve the quality of life of the coastal and island areas of the EU. This is a sector which contributes to the food and nutritional

[4] 12.B "Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products". https://www.un.org/sustainabledevelopment/sustainable-consumption-production/

security of the citizens of Spain and, of course, Europe and which must be exploited from the point of view of the concern for the environment and for the climate.

The EU, in its "Strategic Guidelines for the Sustainable Development of EU Aquaculture" (European Economic and Social Comittee 2021), highlights four priority areas to be considered:

(a) The improvement and streamlining of administrative procedures, given the complexity in obtaining fishing licenses and, at times, their delay.
(b) Coordinated management of the marine area.
(c) Ensuring competitiveness, especially by linking the sector with science, and searching for new production solutions. For example, aquaculture should be considered and treated as a form of agriculture, especially in the case of fish farming in ponds.
(d) Taking care of the fulfillment of the conditions of economic competition in an equitable way among the companies and entrepreneurs of the economic sector that we are considering. In fact, different national or regional legislation for aquaculture may impose different legal requirements on companies, even if they operate in the same sea basin, which in turn carries the risk of distorting competition. This is unfair and goes against the principles of free competition in the EU.

The 2017 scientific opinion called "Food from the oceans" (European Commission 2017) indicates that the only way to obtain a significant increase in food and biomass from the ocean in the short term is to harvest organisms from the lowest levels of the food chain, such as macroalgae and bivalve mollusks. Their conclusions called for some changes:

(1) Improvements in management and increased utilization of wastes in traditional capture fisheries.
(2) Fishing of new wild species that are not, or only marginally, exploited today.
(3) Mariculture of organisms that extract their nutrients directly from the water.
(4) Mariculture of organisms that require feed.

For this reason, the Member States should draw up multiannual national strategic plans for aquaculture which analyze the problems to be solved and establish common objectives and, if possible, indicators to evaluate the progress made toward the achievement of the objectives highlighted above.[5]

[5] **12.6.** Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

Spanish Fishing in the EU

The Spanish fishing sector is currently facing problems derived from the overexploitation of marine fauna resources (Lloret Soriano 2011).[6] Among these problems, we can highlight:

(1) The destruction of the seabed by the various types of fishing, a fact which is linked to the scarcity of the continental shelf of Spanish territorial waters. As is well known, fishing is found in this area of the seabed.
(2) The extraction of immature fish; very small fish that, when fished, prevent them from reaching larger sizes. In the 1980s, a Spanish campaign became popular saying "*Pezqueñines ¡no gracias! Debes dejarlos crecer*".[7] It was an institutional communication from the Fund for the Regulation and Market Organization of Fishery Products and Marine Crops (FROM) to raise consumer awareness.
(3) The mechanization of fishing vessels which has increased their power and with it, the catch levels.

Today, great efforts are being made to achieve a more sustainable fishing sector that can supply food to societies and, at the same time, reduce negative impacts on the environment. The international, national, and local institutions[8] have different objectives, for example:

(1) Increasing aquaculture activities, that is, increasing the production of the sector in our society (FAO 2020).
(2) Establishing specific protection measures in delimited areas of the traditional fishing grounds, which allow the improvement of reproduction conditions of the species of fishing interest and the arrival of fish to adult stages before their subsequent fishing and human consumption.
(3) The establishment of a marine reserve implies a significant recovery of the fishing grounds in which it is located for the reproduction of the underwater species that have been protected (FAO 2020).

One of the international institutions that stands out for its proposals for sustainable fisheries is **The Marine Stewardship Council** (MSC). It is an international non-profit organization that aims to make fishing a sustainable economic activity. To this end, it intends to certify those fishery products that have been obtained through techniques that respect the environment and marine ecosystems with a blue MSC seal. This seal is called "Azulinar" in Spanish and "MSC blue tick" in English (Marine Stewardship Council-MSC 2018).

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[6] https://web.ua.es/es/revista-geographos-giecryal/documentos/articulos/a-la-busqueda-de-un-sector-pesquero-sostenible.pdf?noCache1309623458477.

[7] (baby fish, no thank you, you should let them grow).

[8] For example: European Commission; Economic and Social Comittee; Fundación Observatorio Español de Aquicultura; and Ministerio de Agricultura, Alimentación y Medio Ambiente.

In short, the EU aims to boost the development of the marine sector, promoting greater production of fish, crustaceans, mollusks, algae, and echinoderms from aquaculture and improving the competitiveness of these products, increasing their consumption and their contribution to the food and nutritional security of EU citizens. It insists that this must be done while preserving the proper functioning of marine ecosystems to allow the continued practice of profitable aquaculture and commercial fishing, as well as other sustainable uses of the marine environment.

The EU in its "Strategic Guidelines for the Sustainable Development of EU Aquaculture[9]" is concerned that fish feed should be from sustainable sources, and therefore, nutrient loading should be controlled. Cooperation with researchers is very important in order to achieve sustainable feeds capable of nourishing farmed aquaculture species. Food safety must be ensured, along with product quality and sustainability of production. Moreover, we are warned against forgetting the requirements of economic profitability that make the development of the sector possible, creating more and more new jobs (Bordonado-Bermejo and Jiménez-Manso 2019).[10] Furthermore, emphasis is placed on the development of the emerging economic sector of seaweed aquaculture.

Recovery, Transformation and Resiliency Plan PERTE[11]

The agri-food sector accounts for 20% of the economy in Spain (Morales and Aguilera 2020), specifically, aquaculture production in Spain is 342,900 tons because it is a pioneer in this sector. Spanish culture, gastronomy, traditions, and landscape are closely linked to this sector (APROMAR OPP30 2022). It is a fundamental driving force in the creation of employment and in the production of foodstuffs, thus addressing the needs of the rural population.[12] This food supply and consumption must be sustainable in order to preserve the environment. It is for this purpose that the agri-food plan PERTE has arisen, which we are going to discuss below.

The Recovery, Transformation and Resilience Plan is the strategy for the use of European funds to repair the damage caused by the COVID-19 crisis with sustainable objectives through reforms and investments. Within this recovery strategy, we count on the Strategic Projects for Economic Recovery and Transformation (PERTE in Spanish). We define them as projects of a strategic nature with a great capacity for economic growth, employment and competitiveness of the Spanish economy, and with a high component of public–private collaboration, transversal to the different

[9] Towards a sustainable and competitive European aquaculture sector European Parliament resolution of 12 June 2018 on Towards a sustainable and competitive European aquaculture sector: current situation and future challenges (2017/2118(INI)).

[10] Bordonado Bermejo, MJ y Jiménez Manso, A (2019) Estrategia de Marketing de Seguridad Alimentaria en el I Congreso Nacional de Pesca, 1918.

[11] PERTE in Spanish, stands for El Plan de Recuperación, Transformación y Resiliencia.

[12] 12.b Develop and implement tools to monitor the impact on sustainable development, in order to achieve sustainable tourism that creates jobs and promotes local culture and products. fossil fuel.

administrations. They are open to all types of companies, from SMEs and startups to large companies. The PERTE was approved by the Spanish Council of Ministers on February 8, 2022 (Gobierno de España 2022).

With the PERTE designation, a sector is identified as a key area for the future of the economy. They seek to contribute to economic growth and employment by remedying market failures and/or social challenges with innovative means and added value in R + D + I (Research + Development + Innovation). Needless to say that the quantitative or qualitative value of the companies within each economic sector also becomes crucial.

Due to its beneficial impact, we are going to focus on the agri-food PERTE. It is a set of measures aimed at developing the agri-food chain and providing the necessary tools to deal with future environmental, social, economic, and digital challenges. Its aim is to improve the entire agri-food chain through the digitalization of processes and the incorporation of knowledge and innovation.

Therefore, it consists of the concern with the sustainable supply of sufficient safe and healthy food, to meet the needs of the population. Consumers are increasingly aware of the importance of a demand for healthy and environmentally sustainable food. In order to bring this sustainable supply and demand into line in the market, programs managed by different ministries from Agriculture to Science and Innovation have been included.

The agri-Food PERTE has a twofold interest:

(1) For the economy, for its dragging capacity and potential for transformation by contributing to economic development.
(2) For society, because of its boost to quality employment and its contribution to the demographic challenge and territorial balance.

In short, there are four targets of the agri-Food PERTE:

(1) Improvement in the competitiveness of the agri-food sector in Spain.
(2) Improving the sustainability of the agri-food sector in Spain.
(3) Improving traceability and safety in the agri-food sector in Spain.
(4) Contribution to the demographic challenge as a cross-cutting objective (Gobierno de España 2022).

The PERTE agri-food strategic project has three priority lines of action:

(1) Specific support package for the agri-food industry, with the aim of improving its production processes, linked to its competitiveness, sustainability, and traceability in food production.
(2) Specific measures to support the digital transformation process and to spread to all the agents that form part of its value chain (farmers and livestock breeders and their cooperatives, small and medium-sized production, processing and marketing companies).
(3) Specific measures to support innovation and research to achieve a competitive agri-food sector in all links.

Ultimately, the application of these measures (Bordonado Bermejo 2022)[13] can improve the agri-food chain, strengthening it to face environmental, digital, economic, and social challenges, which will also boost the development of the tourism sector related to the gastronomic culture that is characteristic and peculiar to all regions of Spain (12.B).[14]

PERTE[15] and the Circular Economy

The circular economy can be defined as a production and consumption model which seeks to extend the useful life of products (sharing, reusing, repairing, renting) and which, in practice, translates into reducing the waste generated to a minimum (Economipedia 2022). For this reason, in this research, we include the PERTE of circular economy that has been approved by the Spanish Council of Ministers on March 8, 2022.[16] The circular economy surpasses the traditional linear economic model based on produce, consume, and throw away. This is because it aims to ensure the sustainability of the planet. In Economics, natural resources are finite, which is why it is so important to take care of them and achieve better results in terms of efficiency and competitiveness.

Also, we should highlight the concept of the blue economy for the approach being taken in this research. The blue economy is an approach that affects companies and entrepreneurs globally. The fundamental idea of this approach is that companies should be efficient when producing goods and services. Thus, the blue economy seeks to make the most of available resources, without forgetting that waste must also be used. For the blue economy, waste is considered another source of wealth.[17]

The circular economy PERTE aims to contribute to efforts to achieve a sustainable, decarbonized, resource-efficient, and competitive economy. It is also an opportunity to favor new niches of activity and employment, for example, those associated with recycling, repair, and the service sector.

The circular economy PERTE comprises of 18 measures distributed in two lines of action:

(1) **Actions on key sectors**: textiles, plastics, and capital goods for the renewable energy industry.
(2) **Transversal actions** to promote the circular economy in the company.[18]

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[13] Bordonado Bermejo, MJ (2022) Los retos de conseguir sostenibilidad y desarrollo económico en el sector agroalimentario en España, https://www.esic.edu/rethink.

[14] 12.b Develop and implement tools to monitor the impact on sustainable development, in order to achieve sustainable tourism that creates jobs and promotes local culture and products.

[15] https://planderecuperacion.gob.es/como-acceder-a-los-fondos/pertes/perte-agroalimentario.

[16] https://planderecuperacion.gob.es/preguntas/que-son-los-perte.

[17] https://economipedia.com/definiciones/economia-azul.html.

[18] **12.5.** By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.

Having considered some aspects of the production in the aquaculture sector, in particular, the sustainability problems of fisheries in Spain, and having also commented on the benefits of the PERTE resilience plan applied to the agricultural sector, it is time to focus on **sustainable consumption**, as the other side of the coin in **Sustainable Economic Development (SED)**.

Sustainable Consumption

European Healthy Consumption Organizations

The purpose of this section is to add other organizations that no longer refer to aquaculture, but to **European Healthy Consumption Organizations**. Responsible consumption can be defined as "a way of consuming goods and services to cover our basic needs, providing a better quality of life, but reducing the consumption of natural resources and toxic materials, and also reducing waste emissions and pollutants throughout the life cycle of the service or product. All this in order not to mortgage the future of the next generations".[19]

In terms of sustainable and responsible consumption, it is necessary to study aspects of consumer education and to improve the information provided by public administrations and companies through such means as labeling and instructions. This information is especially important in fish markets and in the hotel and catering sector, especially if we are focusing on the aquaculture sector.

A specific label is proposed for the recognition of sustainable aquaculture products. This could be, for example, the "Azulinar" seal that has been mentioned under the heading of sustainable production. For this purpose, it is necessary to sufficiently inform the consumer and to provide transparency as to the origin, production method, packaging, transport, and so on, of products from the sea. It would also include the methods of fish-slaughtering in accordance with OIE and EFSA guidelines, the equipment used, and their subsequent evaluation and compliance with health and veterinary standards.[20]

The OIE is the World Organization for Animal Health. It is concerned with animal health so that food arrives in perfect condition for human consumption. Food unfit for human consumption contains bacteria, viruses, harmful parasites, or chemical substances that cause more than 200 diseases. Diarrhea is the most common adverse effect resulting from the consumption of contaminated food, making 550 million people sick each year.

Foodborne illnesses, which include a wide range of diseases, are a growing worldwide public health problem, especially among the very young or elderly. A staggering

[19] https://www.consumoteca.com/familia-y-consumo/consumo-sostenible/.

[20] https://www.oie.int/es/que-hacemos/normas/codigos-y-manuales/#ui-id-3.

number of people become ill as a result of eating food contaminated by bacteria, viruses, or parasites.[21]

In order to control this wide range of possible diseases, the European Food Safety Authority (EPSA[22]) provides independent scientific advice on food-related risks. It is responsible for advising on existing and emerging food risks. Its advice is implemented in European legislation and policies and, thus, contributes to protecting consumers from risks in the food chain. In order to achieve the above-mentioned objective, they have to collect scientific data and knowledge, and then publish it. They cooperate with international institutions and with the EU to advise on food safety, building confidence in the system established in Europe.[23]

Also, the European Action Plan "One Health" was determined to fight against antimicrobial resistance.[24] In fact, not only is antibiotic resistance one of the most serious problems in human health, but also in animal health. For this reason, it is necessary to restrict their use when there is a risk of epizootic disease in animal treatment and, as far as this research is concerned, in aquaculture. This is a preventive measure to avoid the repercussion of these treatments on consumers.

Moreover, the Resolution of the European Parliament of the European Sustainable Aquaculture Sector of June 12, 2018,[25] was concerned with improving campaigns to promote the benefits of aquaculture and fish consumption (SAPEA, s.f.).[26] Therefore, it is necessary to establish standards in terms of quality and animal welfare and environmental protection to highlight compliance with these regulations with respect to products imported from non-EU countries. The aforementioned resolution also referred to the dissemination of the label "Raised in the EU". It included the need to promote protected designations of origin, as had already been done in the agricultural sector. It is therefore necessary to launch an institutional communication campaign for all member countries, aimed at consumers and companies in the aquaculture sector to highlight the degree of compliance with the standards of European companies, compared to the lower level of requirements of products imported from third countries.

In line with all that was determined in the resolution, we should add the concern for the welfare of farmed fish during rearing and transportation to points of sale to achieve consumer satisfaction and to publicize the quality of EU products, compared to fish imported from third countries. Within these quality requirements, and seeking harmonization between sustainable production and responsible consumption, new initiatives must be taken into account, such as promoting seaweed aquaculture, a sector

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[21] https://www.woah.org/es/invertir-la-tendencia-de-las-enfermedades-de-los-animales-acuaticos-gracias-a-una-mejor-vigilancia/.

[22] https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/institutions-and-bodies-profiles/efsa_es.

[23] https://www.elconfidencial.com/medioambiente/soy-eco/2021-02-18/pesca-sostenible-biodiversidad-marina-oceanos_2954692/.

[24] https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=legissum:4304077.

[25] https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:52018IP0248&from=IT.

[26] https://www.sapea.info/wp-content/uploads/FFOFINALREPORT.pdf.

of ecological and economic value, with due respect for social and environmental sustainability.

Characteristics of New Consumers (Deloitte 2022)[27]

According to what we have said about responsible consumption, it is necessary to know if the characteristics of the consumer are still the same. In a recent study by Deloitte Digital,[28] they come to the conclusion that the new consumer, who emerged after COVID-19, has different characteristics to the previous one.

Their study proved that there have been many changes in people, society, and the environment that have led to the emergence of a new consumer. Individuals have changed their scale of values, and health and safety are new priorities.[29] A redesign of the structure of Maslow's pyramid is therefore required. The COVID-19 situation has led to increased self-control in spending for fear of future uncertainty. Also, the pandemic has led to digital awareness and socialization, since consumption is increasingly taking place through digital economy systems (12.A).[30]

For its part, society has experienced a growth in the concern and social commitment of brands. Corporate social responsibility is becoming more and more important for companies, and they are continuously interested in informing consumers about their concern for social aspects, including the sustainability in production. In addition, there is more responsibility in consumption and concern for receiving information about companies, their products, and production methods.

Indeed, consumers have acquired a greater capacity for mobilization to demand that entrepreneurs comply with their offers and quality criteria. This last characteristic becomes highly significant for the purposes of this research, namely a greater awareness of the impact of environmental issues on the productive sectors and on commercial activity in general.

All in all, this change in consumer characteristics has to be translated into a business effort to adjust to market demands. Therefore, the challenge for companies remains to get to know their customers, humanize the digital and physical relationship, and reinvent new products and services, all with the concern for Sustainable Economic Development.

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[27] https://www2.deloitte.com/es/es/pages/operations/articles/nuevo-consumidor-despues-del-covid-19.html.

[28] Deloitte-EN-Executive Summary-Consumer year I A.D. (after Covid-19).

[29] 12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

[30] 12.a Assist developing countries in strengthening their scientific and technological capacity to move towards more sustainable consumption and production patterns. https://www.un.org/sustainabledevelopment/es/sustainable-consumption-production/.

Conclusions

This chapter has shown that sustainable development, and more specifically SDG 12, can be implemented in the pyramidal economic structure developed by Jané Solá. That is, Sustainable Sectoral Policies and Sustainable Instrumental Policies are interdependent in implementing Finalist Economic Policies, sustainable development being the main final objective.

With regard to sustainable production, the "Strategic Guidelines for the Sustainable Development of EU Aquaculture" shows that there is still a long way to go for the fisheries sector in Spain. Although it seems to be a forgotten sector in Spain, implementation of quality processes is urgently needed in order to respect the survival of the already threatened below-water ecosystems. It is also necessary to implement new aquaculture plans to manage food from the sea that is unknown to us (algae, microorganisms, new wild species, etc.).

The pandemic resilience plan, PERTE, has proven to be a stimulus for sustainable production in Spain, in that it has become a driver for more sustainable packaging, modern digitized processes, and a boost in innovation to reuse waste and implement the circular economy.

The pandemic has not only prompted us to develop resilient plans in Spanish agriculture, but above all, it has changed the characteristics of consumers around the world. In the post-COVID-19 culture, consumers are more aware of the importance of ensuring health in all sectors and processes of food production. Supported by European policies, in particular by SDG 12, we have learned to mobilize and demand information on production processes which should limit unnecessary consumption, caring for future generations. In short, these new societies require economic policies that prioritize sustainable development and, ultimately, are the ones which are putting pressure on companies and governments to implement the objectives of the Finalist Economic Policies.

In short, it is justified that consumers in Spain have changed as the post-COVID-19 situation has led to social sustainability awareness. We must wait in time to be able to measure whether the governments measures, after implementing, will really achieve the expected economic development.

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SDG 13. Take Urgent Action to Combat Climate Change and Its Impacts

1975–2018: 43 Years of Glacial Retreat in the Incachiriasca Glacier (Nevado Salcantay, Vilcabamba Range, Peru)

Álvaro Navarro, Jose Úbeda, Jesús Gómez, and Ramón Pellitero

Abstract Glaciers are sensitive indicators of climate change, especially small sized tropical glaciers, since they are the most susceptible to any minimal variation of climatic conditions. This study focuses on the analysis of the shrinkage of the Incachiriasca II glacier (72º32'W, 13º21'S; ~ 4950 m) from 1975 to 2018. The first reference of the glacier's delimitation is the annual topographies by Peruvian researchers between 2007 and 2018. This time sequence has been extended to 1975 by analysing 28 LANDSAT images. Our results show a loss of 51.4% (-0.271 km^2) of the glacier's total area: from 0.528 km^2 (1975) to 0.257 km^2 (2018), equivalent to -0.0063 km^{2}yr^{-1} (1.2% yr^{-1}). According to the observed trend, the annual rate of decline has increased considerably, especially since 2010, from 1% in 2001–2010 to 3% in 2010–2018.

Keywords Tropical glaciers · Deglaciation · Climate change · Remote sensing · Tropical Andes

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_13

Introduction

Glaciers retreat is one of the clearest evidences of Climate Change due to its global impact. According to the most recently published World Glacier Monitoring Service report, glaciers have continuously been retreating worldwide for the last 30 years (WGMS 2021). This retreat, however, is not uniform. Glacier mass loss in Northern Europe and the Canadian Arctic region, for example, is less than half the global average, whereas glaciers located in the mid latitudes, such as those in the Alps or the USA nearly double the global mass loss average. There are even areas where glaciers seem to be advancing, such as the well-known Karakorum Anomaly in Central Asia (Farinotti et al. 2020). Tropical glaciers are among the fastest retreating glaciers in the World (UNESCO 2018) and both mass balance measurements and glacier fronts show a pronounced retreat which is accelerating during the XXI century (WGMS 2021). The reason behind is because tropical glaciers are more sensitive to changes in temperature and precipitation than polar and mid latitude ones, due to the lack of contrast in temperature between the cold and hot season. In tropical areas, ablation occurs all year round on the lowest part of the glaciers, resulting in a short-time response of the position of the ice tongue terminus to changes in mass balance, and consequently to changes in climate (Rabatel et al. 2013).

In consequence, tropical glaciers are very sensitive indicators for climate change, but they also play a vital role in the supply of water resources during the dry season in the Andean region, where 99% of tropical glaciers are located, (Pouyaud et al. 2005; Bonshoms et al. 2022). Moreover, glacier retreat in the Tropical Andes frequently entails the creation of new lakes due to meltwater filling glacial overdeepenings revealed after ice disappearance. In many cases, these new lakes are dammed by unstable moraines and under rock and ice masses which can collapse and generate glacial lake outburst floods (GLOFs). GLOFs are one of the most important natural hazards that Andean communities downstream glaciers must face (Emmer et al. 2022). A recent example in the catchment where Incachiriasca glacier is located was the Lake Salkantaycocha huayco (local name for GLOFs), in February 2020, triggered by a rock and ice avalanche invading that proglacial lake in the Salcantay West face (Vilca et al. 2021). Due to their importance in natural hazards and as water resources, glacier monitoring is a highly important topic within the current climate change scenario, especially in the high tropical mountains.

The first glacier monitoring efforts in Peru came after catastrophic events. Although there are some previous works (Oppenheim and Span 1946; Kinzl 1940; Brüggen 1928; Broggi 1943), the initial leap on glacier and glacial lake research came after the catastrophic huayco event that hit Huaraz on December 13th, 1941 (Portocarrero 2009). A second boost on glacier research came after the inauguration of the Cañón del Pato hydroelectric facility in 1958 on the Santa River. Here, the importance of glacial water resources on river discharge made deglaciation a topic worth studying. Glacier studies were primarily focused on the Cordillera Blanca, but the general glacier retreat all across Peru and its consequences on water resources and natural hazards, made all the glaciated areas interesting for glacier research (Ames et al. 1988).

Machu Picchu Historic Site (SHM) was the first Natural Protected Area (NPA) involved in the monitoring of a glacier within its bounds. The Incachiriasca glacier was selected in 2007 for being monitored, due to its accessibility, relatively low gradient, especially in the ablation area, and safety conditions (few crevasses, and not prone to avalanches) (Fig. 1).

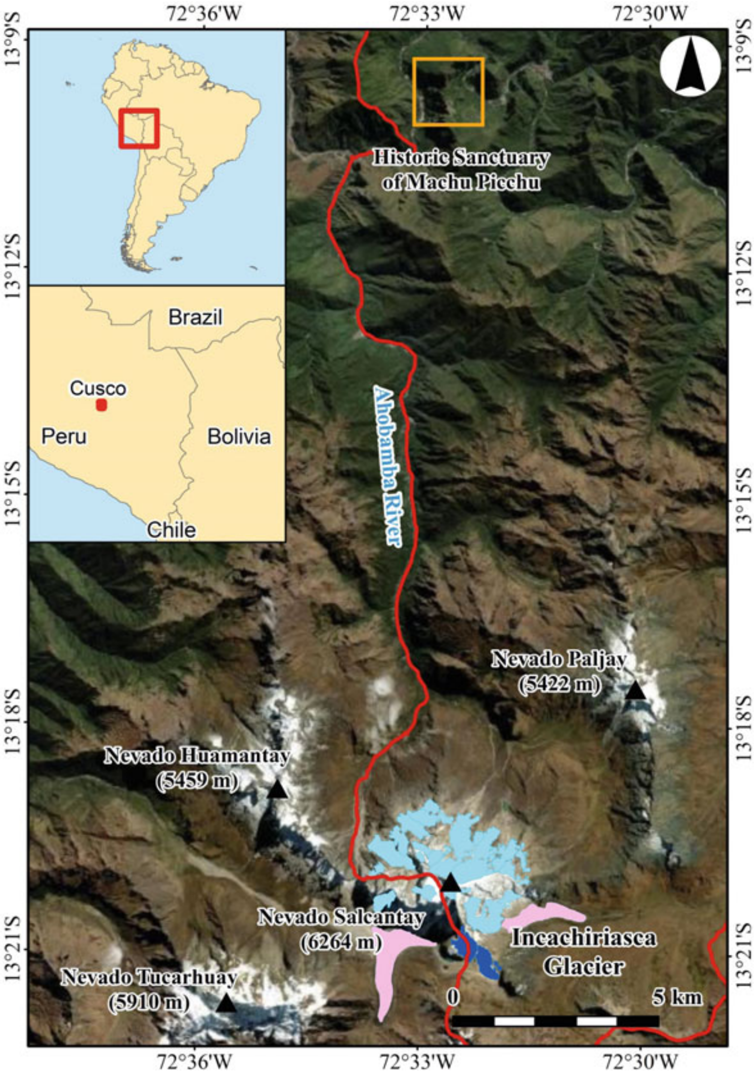

Fig. 1 Limits of the Incachiriasca glacier in 2018 (dark blue) and the rest of white glaciers (light blue) (light blue) and debris covered glaciers (pink) in the Nevado Salcantay mountain. In red line, limits of the Machu Picchu National Sanctuary. The sacred city is highlighted with an orange square. Basemap: World Imagery (Esri)

Study Area

Incachiriasca is located at the foot of the Nevado Salcantay (6264 m), the highest peak in the Vilcabamba range (Cuzco region, Southeast Peru; −13.36º, −72.54º). Vilcabamba is a W–E mountain alignment whose catchments drain to the Amazon basin. Salcantay is part of the permian–triassic Machu Picchu batholith (Fig. 2), in which the combination of a very intense tectonic uplift and strong erosion resulted in the highest peaks of range (Mendoza 2013). The areas with Palaeozoic metamorphic rocks, located southward of the Vilcabamba are generally lower (e.g. Cerro Ampamay, 5418 m).

There are currently 28 glaciers in the Salcantay slopes. Altogether, they cover around 5.32 km^2, being all of them small sized (< 1 km^2), except the debris covered glaciers on its south and northeast face, whose dynamics and span is favoured by the amount of sediments covering their surface, and they are located between 4685 and 6271 m elevation. The Incachiriasca glacier is located in the SE slope of Salcantay and is small sized (0.6 km^2 in 2018). It is split into two ice bodies, Incachiriasca I (INCA-I; 0.29 km^2) and Incachiriasca II (INCA-II; 0.31 km^2, in which this study is focused). INCA-I drains into the Ene basin, whereas INCA-II drains into the Urubamba river. The two mentioned rivers finally drain into the Ucayali.

The study area lies at the border of the Amazon Basin. This is a tropical, relatively humid area, in which daily thermal oscillation is well above the annual oscillation (merely around 1–2 ºC), a typical thermal regime in tropical areas (Kaser and Osmaston 2002). Rainfall regime is related to the latitudinal migration of the Intertropical Convergence Zone (ITCZ). During austral summer (October to April), the ITCZ moves southwards, provoking the rainy season (Clapperton 1993). During the austral winter (May to September), the ITCZ moves to the North, resulting in the dry season in the study area. At 4750 m, Incachiriasca glacier's lowest elevation, total annual rainfall is around 800 mm and annual mean temperature is 1.5 °C (Carlotto et al. 2007).

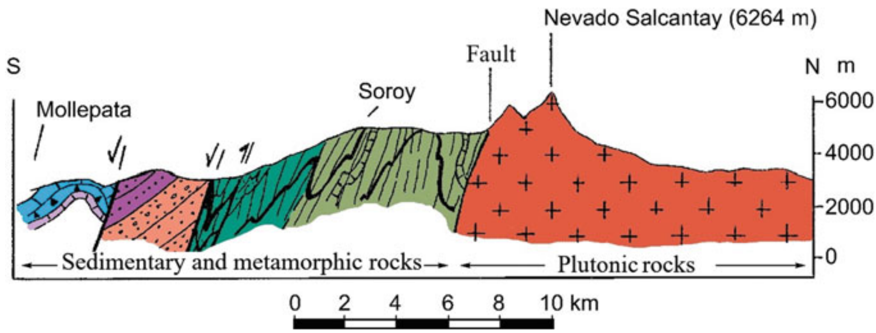

Fig. 2 North-South geological profile, howing the lithologic differences between the North (plutonic rocks) and South (metamorphic and sedimentary rocks). Modified from Marocco (1978) using the International Stratigraphic Comission (2018) colour chart

Methodology

This study analyses the Incachiriasca glacier retreat using fieldwork based monitoring results analysis for the 2007–2018 period and 28 satellite images between 1975 and 2007, so the temporal representativeness is enhanced. INCA-II front retreat and area loss were retrieved from the mentioned data. Satellite imagery comes from the Landsat satellite family, with a 60 m pixel resolution for the 1975 images and 30 m resolution for the 1988 to 2007 images.

Glacier Limit Mapping from Satellite Imagery (1975–2007)

1975–2007 glacier evolution was retrieved from multitemporal Landsat satellite image analysis. Data was downloaded from the USGS Landlook Viewer. Twenty-eight images were used in total: 2 LANDSAT 2, 20 LANDSAT 4–5 TM and 7 LANDSAT 7 (see Table 1). All images were chosen following two conditions: less than 10% cloud cover and date of acquisition between May and September, the season with least snow coverage. Unfortunately, not every year featured suitable images, whereas in other specific years up to four images were needed, in order to choose the most fitting one. We assume the error generated by the partial glacial cover in pixels of the glacier boundary as negligible.

Glacier Delimitation Based on Fieldwork and Topographic Analysis (2007–2018)

Results from the annual fieldworks were used for the aforementioned period, which was made by different institutions (Table 2). Annual topographic measurements were made at the end of the dry season, which is the end of the hydrologic year too, when snow coverage is least extensive. Glacier limit measurements were performed simultaneously to other works, such as mass balance recording. Topographic surveys (X, Y and Z) were made based on visual lines to prism at the glacier border from a GPT 7005 L-Topcon total station. The station was located at a fixed base measured with differential GPS (Figs. 3 and 4).

Data Processing in a Geographic Information System

Glacier area loss and frontal changes were calculated in ArcGIS Pro, where several tasks were made: (1) Glacier surface mapping (1975–2007); (2) GPS topographical survey processing (2007–2018); (3) Glacier retreat database creation; (4) Minimum

Table 1 Collection date and spatial resolution for the LANDSAT images used in this work

Satellite	Year	Date	Resolution (m/pixel)	Area (km^2)	Max. uncertainty (km^2)
LANDSAT 2	1975	25/06/1975	60	0.528	0.313
		31/07/1975			
LANDSAT 4-5 TM	1988	22/06/1988	30	0.425	0.075
		25/08/1988			
	1991	14/05/1991		0.419	0.075
		30/05/1991			
		18/08/1991			
		03/09/1991			
	1994	22/05/1994		0.416	0.075
		25/07/1994			
	1995	09/05/1995		0.412	0.075
		29/08/1995			
	1996	12/06/1996		0.403	0.075
	1997	30/05/1997		0.400	0.075
	1999	21/06/1999		0.382	0.074
LANDSAT 7 ETM+	2001	09/05/2001	30	0.375	0.073
	2004	17/05/2004		0.365	0.073
		18/06/2004			
	2005	11/06/2005		0.358	0.073

Table 2 Fieldwork campaigns in the Incachiriasca glacier undergone by Peruvian institutions

Campaigns	Institutions
2007–2013	SHM[a]—SERNANP[b]. UGRH—ANA[c]
2014–2017	SHM y PNH[d] (SERNANP)
2018	SHM (SERNANP). INAIGEM[e]

[a]*SHM* Santuario Histórico Machu Picchu. [b]*SERNANP* Servicio Nacional de Áreas Naturales Protegidas por el Estado. [c]*UGRH-ANA* Unidad de Glaciología y Recursos Hídricos de la Autoridad Nacional del Agua. [d]*PNH* Parque Nacional Huascarán. [e]*INAIGEM* Instituto Nacional de Investigación en Glaciares y Ecosistemas de Montaña

and average glacier elevation (calculated from a DEM with the *Add Surface Information* tool) and (5) results cartographic representation. An ALOS PALSAR DEM was retrieved from the Japanese Spatial Exploration Agency (JAXA), with a 12.5 pixel resolution, in order to provide elevation data. Glacier front variations for the intervals between 1975, 1988, 1999, 2009 and 2018 were calculated by averaging five distances measured between snouts at different points.

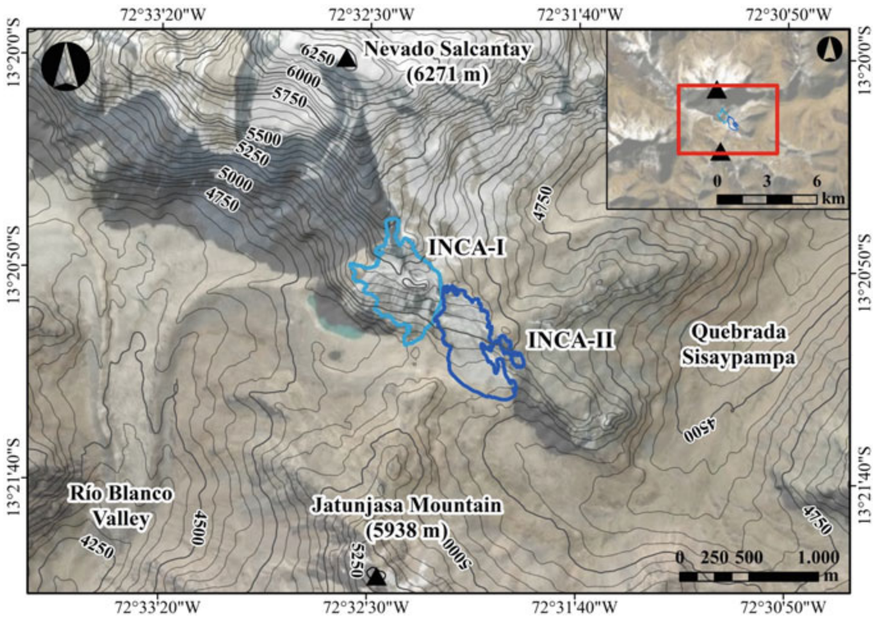

Fig. 3 Limits of the INCA-I and INCA-II glaciers, Southeast of Nevado Salcantay

Results

Out of the 28 glaciers currently existing in Nevado Salcantay, INCA-II is the fifth most extensive, and the largest in the south face. INCA-II is ~ 960 m long (northwest to southeast) and ~ 335 m wide (west to east).

Surface Reduction

INCA-II glacier surface has suffered a 51% reduction during the last 43 years (Fig. 5), from 0.528 km^2 in 1975 to 0.257 km^2 in 2018. The glacier reduction annual rate (RAR) is 0.006 km^2, -1.2% with respect to 1975. This RAR has not been uniform along the considered timespan. The glacier surface reduction was very low in 2011–2012 (0.001 km^2), but from 2014, it accelerated, to the point that the 2017–2018 surface loss was 0.021 km^2, which is a 4% RAR. If results are divided in different time periods, RAR almost tripled since 2010: 1.29% in 1975–1991; 1.05% in 1991–2001; 1.02% in 2001–2010 and 3.06% in 2010–2018 (Fig. 6).

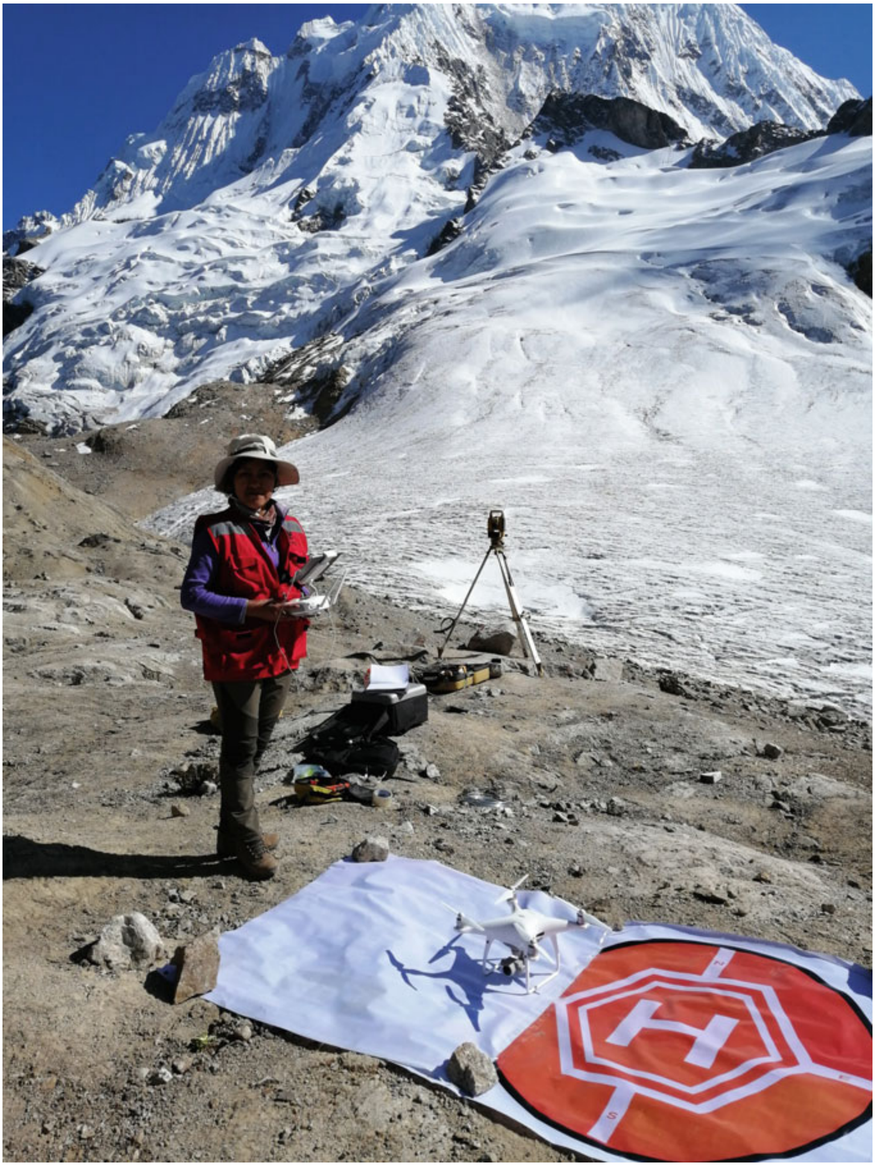

Fig. 4 View of the INCA-II frontal area. The measurement instrument (total station and drone) are also shown

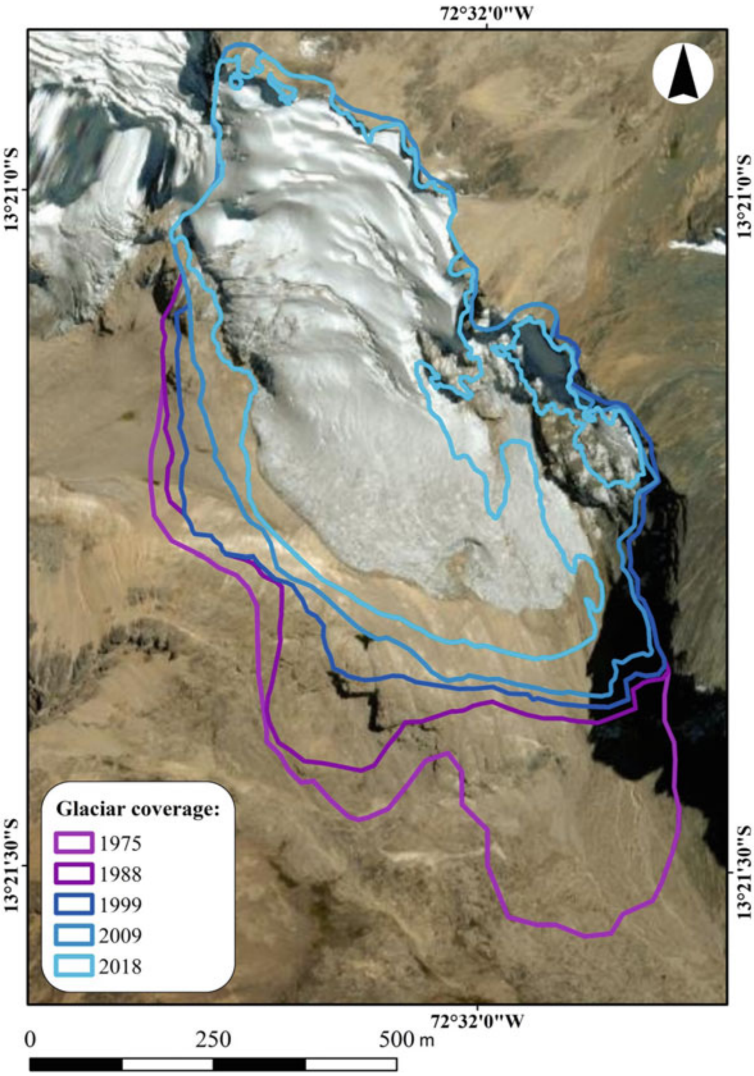

Fig. 5 Limits of the INCA-II glacier during the 5 available dates, on a Digital Globe high resolution aerial image

Glacier Front Retreat

During the 1975–2018 period, the glacier front retreated ~ 415 m, which means a ~ 9.5 m annual retreat rate and a 43% from its longest current length (~ 960 m). Glacier retreat was lowest during the 2011–2012 year (3.83 m) and highest in 2009–2010 (15.77 m). Although in 1975 the Incachiriasca glacier was divided into two small

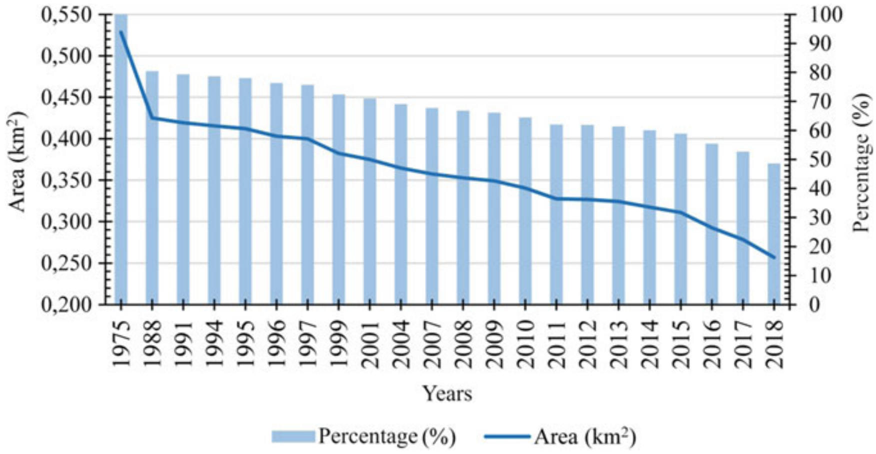

Fig. 6 INCA-II glacier surface evolution (1975–2018) and percentage with respect to the 1975 year

tongues, INCA-I (~ 0.06 km^2) and INCA-II (~0.1 km^2), this study only analyses the retreat of the INCA-II glacier front (Fig. 7), whose evolution is irregular: 133 m of retreat for the period 1975–1988, 114 m for 1988–1999, 82 m for 1999–2009 and 86 m for 2009–2018.

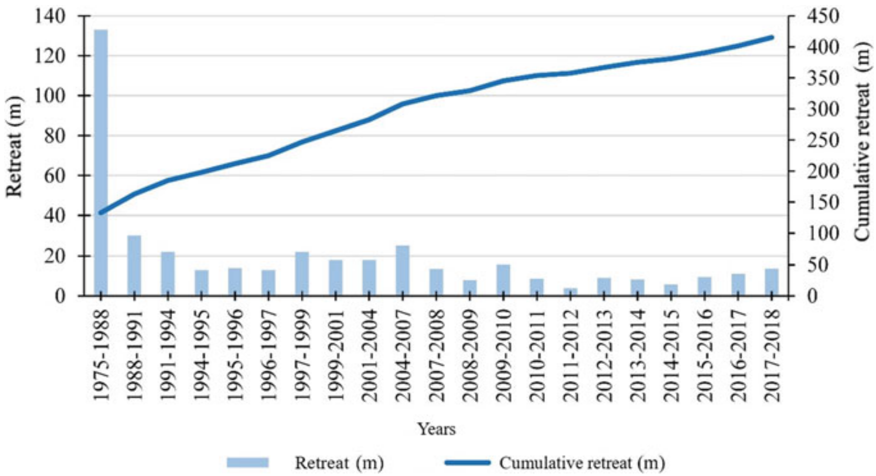

Fig. 7 INCA-I glacier front retreat between 1975 and 2018. The blue line shows the accumulated retreat

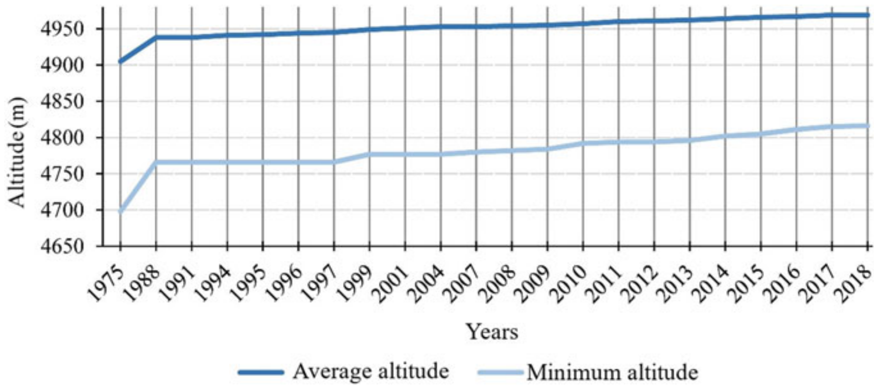

Fig. 8 INCA-II average and minimum glacier elevation between 1975 and 2018

Glacier Minimum and Average Elevation

The hypsometric analysis shows that INCA-II spanned from 4816 to 5170 m. INCA-II is the third lowest glacier in Salcantay. The glacier lowest point has climbed from 4698 m in 1975 to 4766 in 1997 and 4780 in 2007 (Fig. 8). The glacier average elevation of INCA-II in 2018 was 4957 m, the lowest in all the Salcantay white glaciers and a representative elevation of the Equilibrium Line Altitude on favourable aspect in this part of the Andean region.

Discussion

INCA-I and INCA-II Glacier Evolution Since Oppenheim and Spann (1946)

Oppenheim and Spann (1946) did a glaciological expedition to the Nevado Salcantay in 1945. They chose the Incachiriasca glacier thanks to its accessibility and situation, and catalogued it as a "watershed glacier" as its front divided into two branches that flew into two different basins:

- The western front, (INCA-I) finished abruptly in a glacial wall, due to a recent icefall, at a 4595 m elevation.
- The eastern front (INCA-II, described in this chapter) finished in a gentle slope, forming the typical glacial valley tongue.

Field photographies before aerial and satellite imagery are an invaluable data resource, as they permit glacier observations which, in spite of being usually partial, can be used for ice tongue reconstructions at the time they were taken. The lake

Fig. 9 Image of the INCA-I front al moraine taken by Oppenheim and Spann (1946)

and deposit disposition, in the photography published by Oppenheim and Spann (1946) for INCA-I front (Fig. 9), can be discussed alongside our own results. The shown deposits suggest that the picture was taken from the moraine crest that dams a ~ 500 m long lake at present. Oppenheim and Spann (1946) affirmed that their picture was taken 92 m away of the glacier snout. Today, there is a ~ 110 m distance between the moraine crest and the lake, whose dimensions have increased since the mid-twentieth century. Having this into account, we can estimate that INCA-I glacier retreated ~ 860 m between 1945 and 2018.

The recent evolution of INCA-I and INCA-II glaciers has been conditioned, besides the mentioned climate change, by their own shape and the characteristics of the terrain over which they flow. There is a higher retreat in INCA-I front than in INCA-II, which can be explained because INCA-I is a steep glacier placed at the border of a cliff, so it is generally thinner and more sensible to ice wall collapses. Conversely, INCA-II flows into a relatively flat terrain, forming the typical (although rather reduced) valley glacier shape and terminus.

Regional RAR Comparison

Our results for INCA-II ($RAR_{1975\text{-}2018} = 1.2\%$) are similar to other glaciers in the Cuzco region. Veettil and De Souza (2017) deducted a $RAR_{1975\text{-}2015} = 1.2\%$ by analysing satellite images of the northern part of the Vilcanota Range. Drenkhan et al. (2018) found a $RAR_{1988\text{-}2016} = 1.3\%$ using LANDSAT 5 TM and Sentinel-2 MSI images in the Vilcanota-Urubamba basin. Hanshaw and Bookhagen (2014) analysed the Vilcanota range, including the Quelccaya icefield, one of the world's largest in the tropical zone. Based on optical multispectral satellite images (MSS, TM, ETM +, ASTER and KH-9), they estimated a $RAR_{1988\text{-}2010} = 1.4\%$. In addition, the Peruvian national glacier inventory (ANA 2014) found a $RAR_{1970\text{-}2014} = 1.5\%$ for the Vilcabamba range, and previously Salzmann et al. (2013) calculated a

$RAR_{1985\text{-}2006}$ = 1.6% for the Vilcanota range, using multiple sources such as satellite images or a glacier inventory made using aerial photography for 1962 (Ames et al. 1988). However, Suárez et al. (2013) used LANDSAT 5 images in the Vilcabamba Range, and their results show a $RAR_{1991\text{-}2011}$ = 2.4, around 1% higher than any previous work. Finally, Seehaus et al. (2019) used Tandem-X and SRTM radar imagery to infer glacial retreat and mass loss in the Peruvian Andes, dividing the glacier population into three different areas (Cordillera Blanca, wet and dry Southern Andes). They found a more pronounced retreat in Cordillera Blanca and the wet Southern Andes, where Incachiriasca is located, than on the dry, coastal region. Also, they suggested an accelerated retreat during the last decade, a fact that agrees with our results.

All in all, our results are equivalent to those by Veettil and De Souza (2017) and similar to all the other contributions, except Suárez et al. (2013). Our approach shows two main differences with the aforementioned contributions: 1. It studies a single glacier, rather than an entire range, which can make it statistically less representative, but 2. It is based not only on satellite/aerial images, but also on a long data series based on fieldwork, which is the most representative directly obtained dataset for the Cuzco region.

The correlation of results opens up new research possibilities, such as the extrapolation of local/regional results to other scales. In order to check this possibility, new experiments about the comparison between satellite and directly obtained data should be undergone.

Relation Between Glacier Size and RAR

Racovitenau et al. (2008); Vuille et al. (2008); Schauwecker et al. (2014), Seehaus et al. (2019) and Schoolmeester et al. (2018) in Cordillera Blanca agree that deglaciation affects more rapidly and severely to small glaciers (< 1 km^2). Our conclusions on the RAR of Incachiriasca support this idea. The Peruvian national glacier inventory shows that ~ 87% of the Peruvian glaciers are small sized (< 1 km^2). The Vilcabamba range is one of the glaciated ones that shows a higher small glacier proportion (~ 92%), whereas for example in the Cordillera Blanca, this proportion is ~ 81%. Although in these two cases the proportion is high, we can suggest that the 11% difference in small glacier population can be related with the RAR that are observed in both areas: 0.7% in Cordillera Blanca (averaged from Baraer et al. 2012 and ANA 2014) and 1.5% in the Cuzco region glaciers (averaged from Suárez et al. 2013; Salzmann et al. 2013; ANA 2014; Hanshaw and Bookhagen 2014; Veettil and De Souza 2017; Drenkhan et al. 2018 and this work).

The combination of satellite image analysis and fieldwork measurements has permitted tracking the glacial retreat in the INCA-II glacier during 43 years (1975–2018). The availability of directly acquired data is invaluable; hence, it is very important keeping on doing the annual monitoring tasks. The result will be more statistically representative data and the possibility to relate glacier retreat and the positive and negative El Niño Southern Oscillation (ENSO) events, which have been described to directly influence on glacier evolution in the Peruvian Andes (Chevallier et al. 2011). Likewise, glacier retreat could be related to changes in the ZCIT southward shift.

Andean tropical glaciers are retreating at a very fast pace since the 1970s. This reality should encourage those countries whose water resources depend on them, such as Peru, to simulate glacier and water resources evolution scenarios, in order to better adapt their water management policies.

Conclusions, Implications and Management Actions

The main conclusions in this contribution are:

- The INCA-II glacier has lost in 2018 a 51.4% area with respect to 1975, 0.007 $km^2\ yr^{-1}$, which means a RAR = 1.2%.
- INCA-II shows an increasing RAR along the last 43 years: 1.29% (1975–1991); 1.05% (1991–2001); 1.02% (2001–2010) and 3.06% (2010–2018). Data suggests that deglaciation has tripled during the last 10 years.
- Our INCA-II $RAR_{1975\text{-}2018}$ results are coherent with other RAR for glaciers in the Cuzco region which, as a whole (1.5%) are higher than those reported in the Cordillera Blanca (0.7%). This higher retreat rate seems to be in relation to the general small size of Cuzco region glaciers, which makes them more sensitive to climate change.

Accelerated glacier shrinkage has three main implications for future sustainable development. First, there is a loss in the landscape and natural heritage, so insufficiently high mountains will no longer feature glaciers. Second, there is a loss on water storage, which will be important, not only in regions where precipitation is lower (eastward and southward of the Peruvian Andes), but also in the mountains of the Amazon, where the dry season will probably be longer. Water loss is especially relevant during that season, where meltwater has been measured to mean up to 70% of the total river water discharge in the Cordillera Blanca (Baraer et al. 2012). Finally, the ongoing glacier retreat will likely provoke the formation of new unstable lakes where rock and icefall could trigger GLOFs.

Because global warming is a trend that cannot be locally addressed, local management implications should focus on adaptation to the new situation. The first measure should be more thorough research on the current situation and future perspectives of the solid water stored in the nevados. Also, any potential lakes should be foreseen and mapped. Subsequently, valley areas that depend on glacial water resources or simply located downstream glaciated areas should undergo water and risk management plans, in order to adapt to water resources shrinkage and enhanced GLOF hazards. Finally, raising awareness of local communities on the implications of the deglaciation issue is paramount. Only communities which are sensitive to the problem of glacial resources loss will involve in the needed water and land management changes proposed by any sustainable development planning.

Acknowledgements This study has been possible thanks to the fieldwork undergone by technicians and researchers from the following Peruvian institutions: Santuario Histórico de Machu Picchu—SHM (Servicio Nacional de Areas Naturales Protegidas-SERNANP—Ministerio del Ambiente-MINAM), Parque Nacional Huascarán (Servicio Nacional de Áreas Naturales Protegidas-SERNANP—Ministerio del Ambiente-MINAM), Área de Inventario de Glaciares y Lagunas de la Autoridad Nacional del Agua (ANA) and the Instituto Nacional de Investigación en Glaciares y Ecosistemas de Montaña (INAIGEM). We specifically thank Jessica Morón, Gysela Ladera and Israel Aragón (SHMP) for their support. This research has been supported by the following research projects: PERMAFROST ENSO research project (FONDECYT 081-2021), Spanish Ministry of Science PID2020-113247RA-C22 and UNED "Young Talent Projects" 2021V/-TAJOV/005. Finally, Esri Spain, the NGO Guías de Espeleología y Montaña and Canal de Isabel II, the public institution for water supply in Madrid (Spain) have invaluably aided in this research.

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SDG 14. Conserve and Sustainably Use the Oceans, Seas, and Marine Resources for Sustainable Development

Jellyfish Distribution and Abundance on the Southern Coast of the Iberian Peninsula

Oliver Gutiérrez-Hernández and Antonio Rubio Gómez

Abstract Jellyfish have a worldwide distribution and are unfortunately renowned for their direct adverse effects on human activities: tourism, fishing, and aquaculture. Although recent research suggests that jellyfish populations are increasing, evidence also shows that jellyfish abundances fluctuate with climatic cycles and spatial patterns. The ocean is impressively large on a human scale and considerably impacts the weather, temperature, and food supply of humans and other organisms. Despite its size and impact on the lives of every organism, the ocean remains a great unknown. Marine geography explores the environment of the oceans and seas and the relationship between society and these water bodies and investigates global challenges of changing ocean systems. However, until the beginning of the twenty-first century, there were few studies of the ocean in geography. This chapter deals with Marine Geography and the Sustainable Development Goals (Goal 14: life below water) to analyze the sightings of jellyfish and other gelatinous organisms on the southern coasts of the Iberian Peninsula (Andalusia region, southern Spain) by using Geographic Information Systems (GIS). Our results show that jellyfish sightings and other gelatinous organisms show spatial and temporal patterns. *Pelagia noctiluca* was the most observed jellyfish species in the study area, mainly on the Mediterranean coast of Andalusia (southern Spain). Mapping jellyfish sightings can contribute to integrated coastal management regarding human activities and environmental problems.

Keywords Marine Geography · Biological risks · *Pelagia noctiluca* · Sustainable development goals (SDG) · Integrated coastal area management

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_14

Introduction

The Impact of Jellyfish Blooms

Jellyfish are invertebrates that belong to the cnidaria group, primitive organisms that have populated the seas for more than 500 million years (Killi and Mariottini 2018). These gelatinous organisms flow along with marine currents by contracting and expanding their bodies (Satterlie 2002). The jellyfish's life cycle is short (Fig. 1), about eight months (Spring et al. 2000), and broadly it includes two major phases: a medusoid form, which is the free, swimming, and sexual way of life, and a polypoid or polyp form, which reproduces asexually and remains fixed to the substrate (Lucas 2001).

There are approximately 4000 species globally (Purcell and Angel 2010). These gelatinous organisms depend on oceanographic and atmospheric conditions, which affect the seas and oceans on different spatial and temporal scales (Mills 2001). However, the global increase in jellyfish would impact the environmental degradation of marine ecosystems (Heim-Ballew and Olsen 2019). In this sense, the proliferation of jellyfish is related to global warming (Purcell 2005).

Jellyfish can often form swarms reaching the coast, which can be potentially harmful, especially for bathers, because of the stinging capacity that many gelatinous organisms possess (Condon et al. 2013). In fact, jellyfish have tentacles with

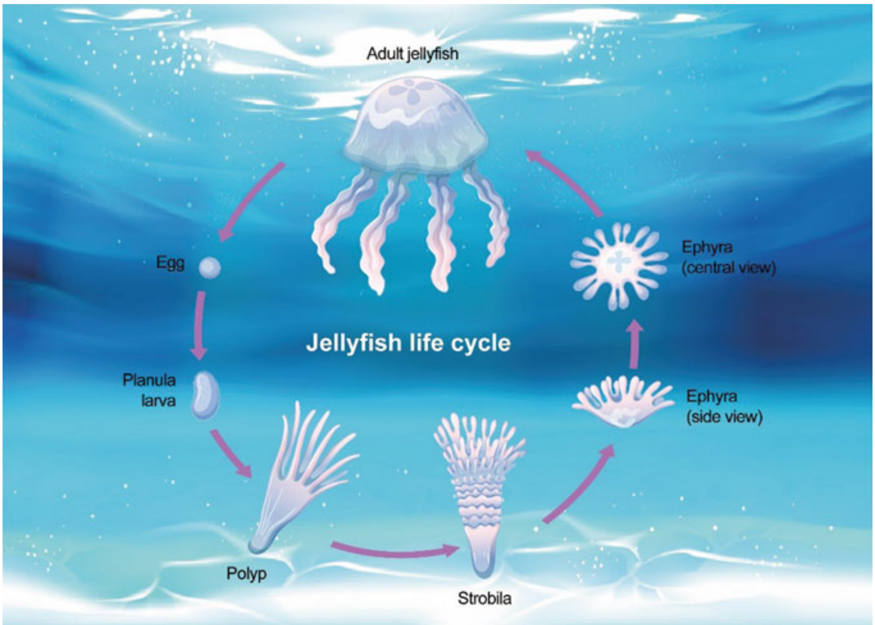

Fig. 1 An overview of the jellyfish life cycle. *Source* own elaboration

sharp capsules filled with a poisonous stinging liquid that they can release through a filament once they contact skin to inoculate the poison (Mariottini and Pane 2010). The sting produces a toxic reaction that can be local and/or systemic, and sometimes, the effects are hazardous to human health (Li et al. 2013). However, only 10–15 species of stinging are hazardous to human life (Gershwin et al. 2010).

Jellyfish blooms can harm sun and beach tourism when they reach the coast but also harm fishing activities (Nunes et al. 2015; Robinson and Wilson 2011). When jellyfish swarms invade beaches, tourism is affected, frequently forbidding bathing to prevent stings. Often, beaches do not reach the point of closure; still, the number of jellyfish is such that it is impossible to bathe or even enjoy a beach day out of the water, which has led to greater attention from the scientific community (Bordehore et al. 2016). Rising ocean temperatures and overfishing enable jellyfish populations to grow at explosive rates (Fig. 2).

The Mediterranean Region is one of the most popular tourist destinations globally (World Tourism Organization 2019), where tourist activity is mainly concentrated in coastal areas connected to sun and beach tourism (Tugcu 2014). The main tourist areas are those related to sun and beach tourism: the Balearic Islands, Canary Islands, and the peninsular Mediterranean coast (Pardo Abad 2013). An increase in jellyfish numbers could affect tourists' experience and choice of a holiday destination, potentially leading to a significant decrease in the volume of tourism in an area frequently affected by jellyfish outbreaks (Ruiz-Frau 2022).

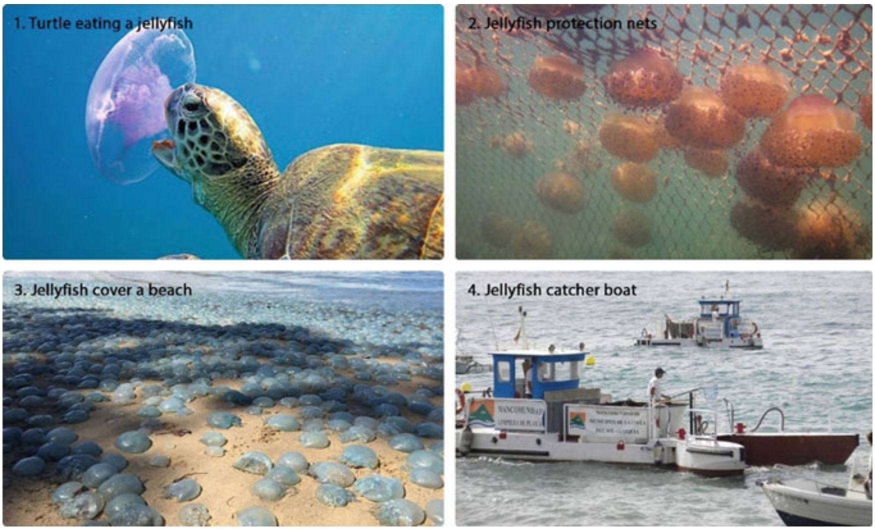

Fig. 2 Jellyfish and global change. *Source* own elaboration based on the original photos from 1, 2, 3, 4

The Role of Marine Geography

Oceans and seas are much more important than we usually represent them. The Spilhaus map projection was developed in 1942 by Dr. Spilhaus: Oceans and seas come together to form a single, continuous body of water (Spilhaus and Miller 1948). This projection helps us visualize our oceans much more connected than we think (Fig. 3).

The Earth's fluid domain is the hydrosphere, which mainly includes the body of water in the world' oceans (Strahler 2013). Indeed, most water on Earth is stored in the oceans. Although geographers use the term ocean to refer to these large water bodies, the terminology for smaller areas of water more closely associated with land is inconsistently applied. Generally, the following largest water bodies are considered seas, subdivisions of the oceans, and partially enclosed by land (Arbogast 2014).

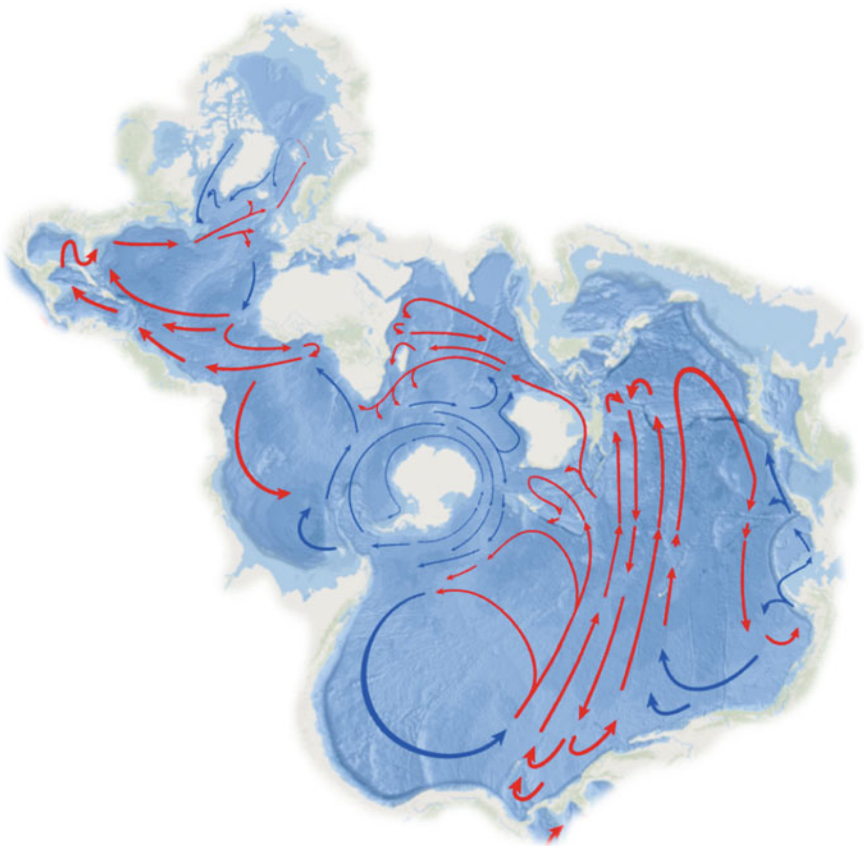

Fig. 3 The Spilhaus World Ocean. *Source* own elaboration adapted from John Nelson (ESRI). *Note* the red arrows illustrate warm water currents, and the blue represents cold water currents

The ocean is impressively large on a human scale—it covers 331 million square kilometers of Earth's surface. The ocean's average depth is about 3682 m, and the volume of seawater is 1.3 billion cubic kilometers (Garrison and Ellis 2014). Because of this, the ocean considerably impacts weather, temperature, and the food supply of humans and other organisms (Longhurst 2006; Steffen et al. 2018). Despite its size and impact on the lives of every organism, the ocean remains a great unknown.

Until the beginning of the twenty-first century, there were few studies of the ocean in geography. Francois Doumenge was one of the most important pioneers of Marine Geography; his work focused on oceanography and fisheries' socio-economics (Doumenge 1965). Geographers have recently contributed to interdisciplinary oceanographic research, primarily through remote sensing and GIS (Breman 2002). In this sense, the explosion of ocean-related research in geography since the 1990s has primarily been in human and environmental geography (Steinberg 2013).

Covering about 70% of the Earth's surface, the oceans influence the weather on local to global scales, while climate changes can alter many properties of the oceans (Wells 2012). These effects could substantially alter the biodiversity and productivity of ocean ecosystems: Interactions between the oceans and atmosphere occur slowly over many months to years (Ferrera 2016). So does the water movement within the oceans, including mixing deep and shallow waters; thus, trends can persist for decades, centuries, or longer (Vallis 2017).

Concerning the *Sustainable Development Goals* (United Nations 2015), Goal 14 is about life below water because the ocean drives global systems that make the Earth habitable for humankind. This chapter deals with Marine Geography to study the sightings of jellyfish and other gelatinous organisms on the southern coasts of the Iberian Peninsula (Andalusia region, southern Spain) by using Geographic Information Systems (GIS). We hypothesize that spatio-temporal and geographical patterns explain the distribution of jellyfish and other gelatinous organisms on the Andalusian coasts, and mapping jellyfish sightings can help us achieve our goals.

Materials and Methods

The Andalusian Coast (Southern Spain)

The study area (Fig. 4) covers the coastal municipalities of the Autonomous Community of Andalusia (southern Spain), the southernmost region of continental Europe and one of the westernmost areas of Eurasia (López Ontiveros 2003; López Palomeque and Plaza Gutiérrez 2019). Despite technical advances, the seabed of Spain continues to be one of the least known places in the country (Tapiador 2020).

The study area includes a coastal strip by the Atlantic Ocean in the Andalusian provinces of Huelva and Cadiz. On the Mediterranean Sea, in Almeria, Granada, Malaga, and Cadiz, where the Atlantic Ocean and the Mediterranean Sea exchange water through the Strait of Gibraltar (Lacombe and Richez 1982; Garrett et al. 1990;

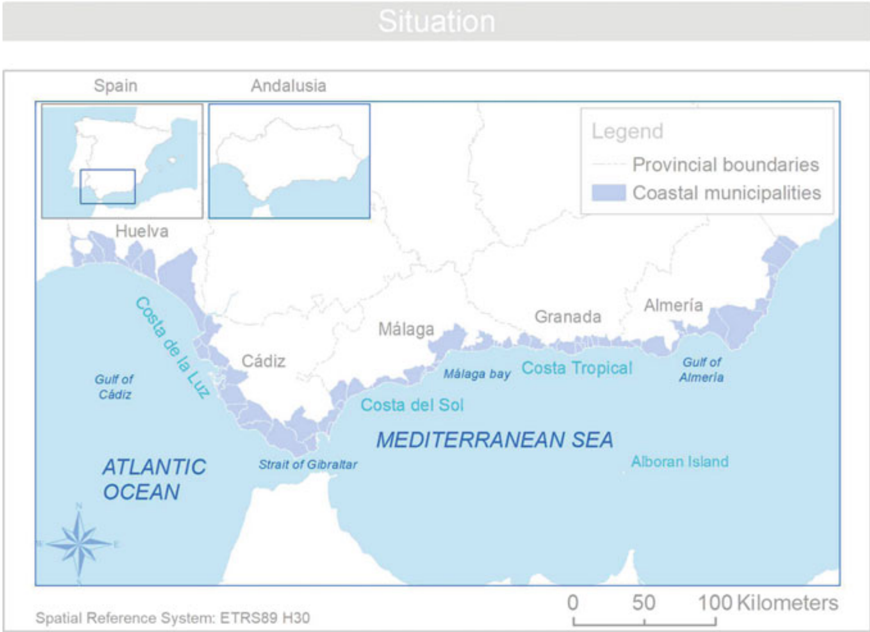

Fig. 4 Location of the study area. *Source* own elaboration

Bryden et al. 1994; Soto-Navarro et al. 2010). The research was carried out in the coastal regions of the 61 coastal municipalities that comprise the 886 km of coastline in the Andalusia region.

From the climatic point of view, Andalusian is located between the midlatitudes and the intertropical zone of the planet (Gómez-Zotano et al. 2015). This region is located in a mesothermal climate conditioned by the seasonal oscillation of the Azores high (Gil Olcina and Olcina Cantos 2017).

According to Ojeda Zújar (2003), the Andalusian coasts are defined by a great duality that differentiates the Atlantic and Mediterranean basins (López Ontiveros 2003). In the Atlantic basin, the oceanographic characteristics are defined by its opening to the Atlantic, which translates into cooler temperatures and lower salinity than the waters of the Mediterranean, long-distance background waves (*fetch*), and the existence of a considerable tidal range (mesomareal coast). On the contrary, the Mediterranean basin is surrounded by land that makes up a sea basin with distinct characteristics to the neighboring waters of the Atlantic. This translates into a higher temperature, higher salinity, lower wave activity, and a micromareal coastline. However, the Mediterranean Sea is in touch with those of the Atlantic Ocean through the Strait of Gibraltar, where oceanographic influences from the neighboring ocean can penetrate.

Tourism is one of the leading agents shaping the territorial, socio-economic, and cultural reality of the Autonomous Community of Andalusia (Caravaca Barroso and

Fernández Tabales 2003; Sarrión-Gavilán et al. 2015). After the Balearic Islands and the Canary Islands, Andalusia is the region with the largest share of tourism in the regional economy. The coastal area of the Autonomous Community of Andalusia is the main livelihood of the Andalusian tourism sector. However, the highest demand for tourism is concentrated in the summer, especially in July and August, and is related to sun and beach tourism (Duro 2016).

GIS Analysis of Jellyfish Sightings

Our research carried out a spatio-temporal analysis of jellyfish sightings on the Andalusian coast using Geographic Information Systems (GIS) based on the methodology applied by Rubio Gómez and Gutiérrez-Hernández (2020).

For this purpose, we used the records of the database called *Avistamientos de Medusas en el Litoral* (Jellyfish Sightings on the Coast) (REDIAM 2018), which are based on an update of the works of Prieto and Navarro (2013), which includes geo-referenced and multi-temporal data (1994–2017) on jellyfish sightings on the Andalusian coast: date, location, abundance, species, etc. This database is stored in a *shapefile* GIS format and includes a complete account of metadata and auxiliary information that documents the nature of the data.

Furthermore, we gathered data from the *Medusapp application—Jellyfish sighting and sting reporting system through citizen science* (Blasco Talavan et al. 2016), which is available for 2018 and includes data on location and date of capture, abundance, and type of species (Fig. 5). Unlike the previous ones, this data is not available in *shapefile* GIS format, and we integrated these data into a Geographic Information System (GIS).

We used GIS tools for capturing and editing geographic information to incorporate the data into the GIS, essentially the sightings of jellyfish and other marine gelatinous organisms recorded by *Rediam* and *Medusapp*. For example, vector geoprocessing is carried out to count sightings (points) on polygons (municipalities, grids). In this way, we defined the characteristics of the sightings at a municipal level. Since some municipalities have very different coastlines, the comparison would be distorted by this factor. Therefore, we also developed a mapping of sightings based on a 5 × 5 km grid to homogeneously quantify the sightings of jellyfish and other marine gelatinous organisms. Finally, we produced the mapping with GIS mapping and layout tools.

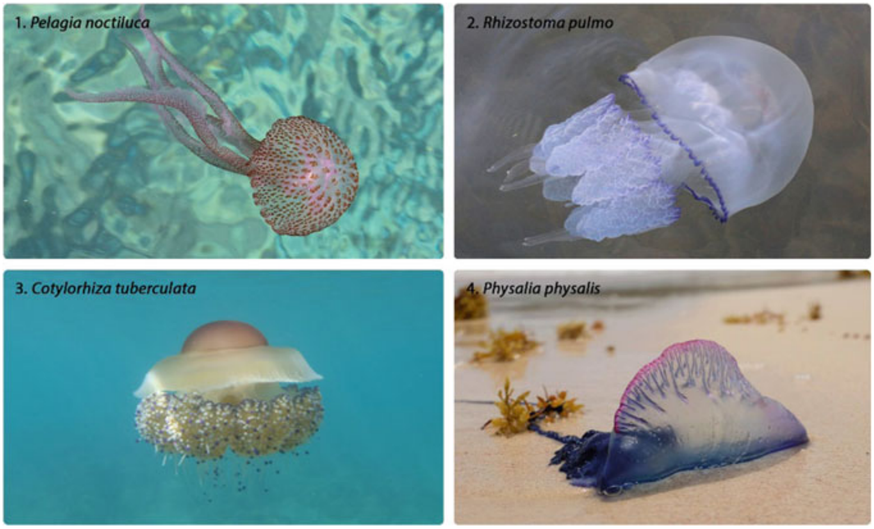

Fig. 5 Jellyfish and other gelatinous organisms of the study area observed previously. *Source* own elaboration based on the original photos from Don Loarie (1), Vitalii Khustochka (2), Dimitris Siskopoulos (3), and Peter Burka (4)

Results and Discussion

Distribution and Abundance of Jellyfish Sightings

According to the data integrated into our Geographic Information System, we counted 1910 records of jellyfish sightings, incorporating the data of Rediam (1430 presence records) and *Medusapp* (480 presence records). On the one hand, when we analyzed the year-on-year evolution, we discovered an alternation between years with many sightings and years with few. We also detected a growing trend toward a more significant number of sightings. Most of the sightings occurred in July, August, and September. When analyzing *Medusapp* data for 2018 only, we found that most observations were concentrated between 10:15 and 15:15, with the median at noon. Nevertheless, this data clearly expresses the observer's bias concerning the hours users frequent the bathing areas on the beaches (Arazy and Malkinson 2021).

The distribution of the number of sightings by identified types yielded the following results (Table 1). *Pelagia noctiluca* accounted for 52.3% of jellyfish sightings. The Portuguese man o' war (*Physalia physalis*), an aquatic organism often classified by its jellyfish-like appearance, accounted for almost 10% of sightings. Also noteworthy were jellyfish sightings of the genus *Rhizostoma* (9.21%) and *Cotylorhiza tuberculata* (9%).

Table 1 Distribution of jellyfish sightings by species

Species	Observations	%
Pelagia noctiluca	999	52.3
Physalia physalis	189	9.9
Cotylorhiza tuberculata	173	9.06
Unidentified species	131	6.86
Rhizostoma luteum	130	6.81
Aurelia aurita	63	3.3
Bolinopsis vitrea	59	3.09
Rhizostoma pulmo	36	1.88
Velella velella	19	0.99
Catostylus tagi	18	0.94
Carybdea marsupialis	15	0.79
Salp	12	0.63
Salpa maxima	11	0.58
Rhizostoma sp	10	0.52
Mnemiopsis Leidyi	8	0.42
Olindias phosphorica	8	0.42
Leucothe multicornis	6	0.32
Porpita porpita	4	0.21
Cestus veneris	3	0.16
Chrysaora hysoscella	3	0.16
Ctenophora	3	0.16
Ascidiacea	2	0.1
Abylopsis tetragona	1	0.05
Aequorea forskalea	1	0.05
Beroe sp	1	0.05
Forskalia edwardsii	1	0.05
Pelagia benovici	1	0.05
Phacellophora camtschatica	1	0.05
Phyllorhiza punctata	1	0.05
Thetys vagina	1	0.05

Source Own elaboration based on Rubio Gómez and Gutiérrez-Hernández (2020)

As shown in Fig. 6, *Pelagia noctiluca* is a species mainly sighted in the Mediterranean Sea. Our data are consistent with previous studies. *Pelagia noctiluca* is considered the most frequent jellyfish in the Mediterranean Sea (Ballesteros et al. 2021), mainly in the Western Mediterranean Sea (Milisenda et al. 2018; Pastor-Prieto et al. 2021).

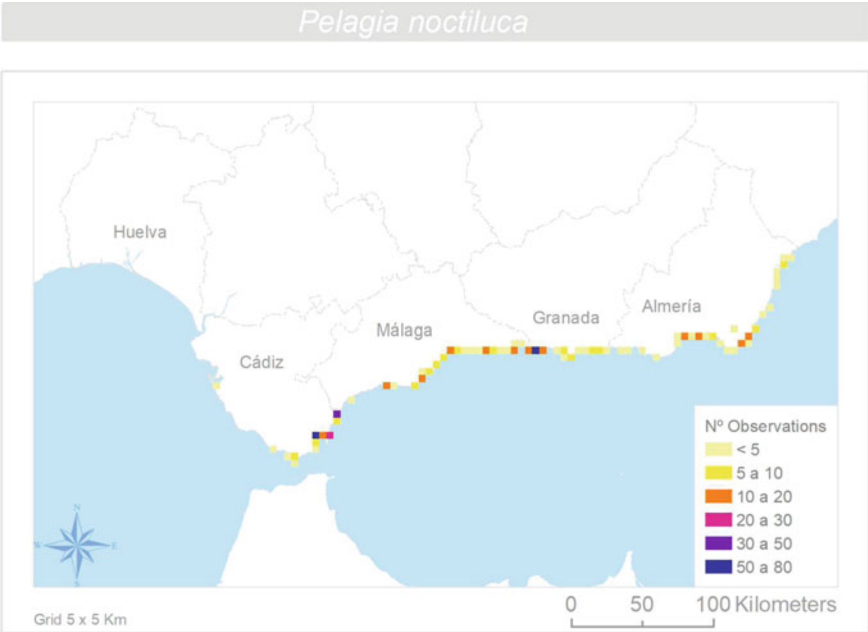

Fig. 6 Distribution and abundance of *Pelagia noctiluca*. *Source* own elaboration

Canepa et al. (2014) found on the Spanish Catalan coast *that Pelagia noctiluca* occurs in the most significant concentrations and reaches near marine canyons. According to these authors, the arrival of *Pelagia noctiluca* to the coast depends firstly on the offshore production of jellyfish. In this sense, and following the explanation of these authors, oceanographic structures like fronts enhance and maintain high levels of biological production and provide ideal conditions for jellyfish feeding, growth, and reproduction (Canepa et al. 2014). This observation could be applied in our study area, although it would require a more detailed investigation. In addition, oceanographic factors should be considered on a regional scale. For example, two highly variable surface anticyclonic gyres exist in the Western Alboran Sea (Sánchez-Garrido et al. 2013; Oguz et al. 2014). This western Alboran gyre is due to the incoming of the Atlantic water jet through the Strait of Gibraltar. Thus, Bellido et al. (2020) suggest that jellyfish may be pushed from the oceanic western anticyclonic gyre of the Alboran Sea to the northern coast by eddies that are formed when westerly winds and the Atlantic jet weaken this gyre.

The Portuguese man o' war (*Physalia physalis*) is often called a jellyfish but is actually a species of siphonophore, a group of closely related animals to jellyfish (Munro et al. 2019). *Physalia physalis* was more frequent in the Atlantic Ocean (Fig. 7)*;* it was also sighted in many parts of the Andalusian Mediterranean coast. Our data closely resemble those obtained by Prieto and Navarro (2013). *Physalia physalis* completes its life cycle in the ocean, and the Alboran Sea surface currents could behave as physical barriers to the flow toward the western Mediterranean (Tiralongo et al. 2022). A peculiarity related to the temporal distribution (annual and year-on-year) of the Portuguese man o' war sightings is worth highlighting. Over 90% of sightings occurred in spring, especially in April (65%), followed by March (21%) and February (7%). On a year-on-year basis, sightings were concentrated in 2010, 2013, and 2018, years in which rainfall was abundant and associated with Atlantic storms, according to the data consulted in the Climate Subsystem of the Ministry of the Environment Junta de Andalucía. These episodes coincided with successive negative phases of the North Atlantic Oscillation (NAO), of greater intensity and duration in 2010 and 2013 and less intensity and duration in 2018, although many later episodes concentrated at the end of the winter (Prieto et al. 2015; Rubio Gómez and Gutiérrez-Hernández 2020).

Table 2 shows the geographic distribution of municipalities' number of jellyfish sightings and other marine gelatinous organisms. 83.7% of sightings were recorded on the Mediterranean coast and 17.3% on the Atlantic coast. By province, 26.33% of sightings were recorded in Granada, 25.60% in Malaga, 23.92% in Cadiz, 19.84% in Almeria, and 4.29% in Huelva. We, therefore, see an exceptionally high concentration of sightings in the province of Granada, which has the smallest stretch of coastline, 75.6 km. More precisely, the sections with the highest concentration of sightings are found in two municipalities in the province of Granada, Almuñécar, and Motril, where

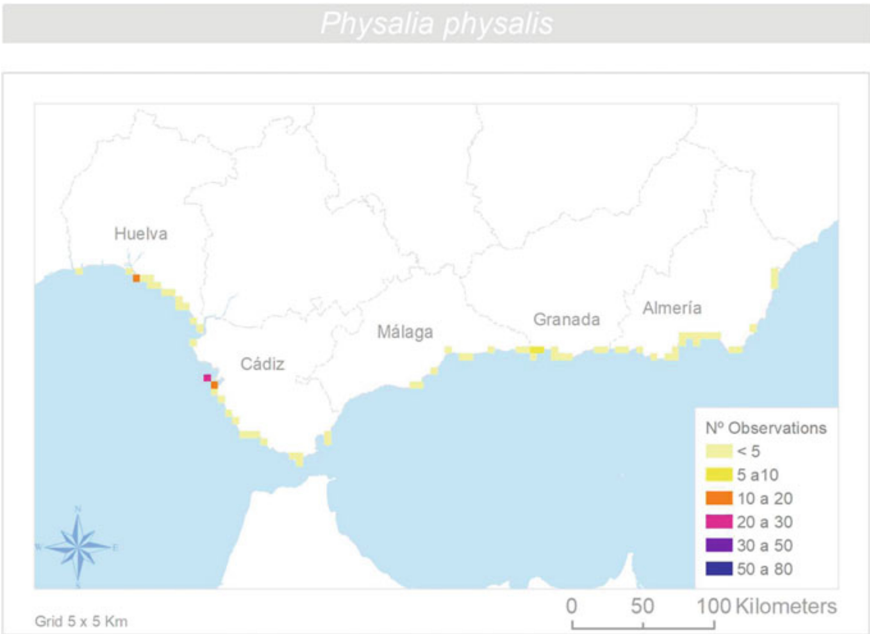

Fig. 7 Distribution and abundance of *Physalia physalis*. *Source* own elaboration

over 20% of the total sightings of jellyfish and other gelatinous aquatic organisms produced in Andalusia were concentrated.

Finally, according to the deviations around the average of the observed sightings, a cartography that classifies the relative exposure levels by coastal sections concerning the arrival of jellyfish can be elaborated (Fig. 8).

Thus, the coastal stretch extending from Torrox-Nerja to Almuñécar-Motril displayed the highest concentration levels of jellyfish. Intermediate, above-average levels are experienced toward the Ensenada de Málaga, consistent across the Bay of Algeciras and the Gulf of Almería. The lowest concentration levels are generally found on the Atlantic coast, except on the Bay of Cadiz. Next, we will discuss our results.

Overall Picture Implications for Coastal Management

Our data found a seasonal curve in the distribution of jellyfish sightings, with highs in summer, and an increasing trend in the number of sightings, alternating years of more or less abundance. However, with the data gathered, we are unable to directly relate an increase in the sighting record to the fact that there is a general increase in the population of these aquatic organisms. This aspect has been discussed by Mills (2001) or Condon et al. (2013), as tempting as the influence of global warming (Purcell 2005) or losing biodiversity induced by anthropogenic activity may be (Purcell et al. 2007).

Most of the sightings in the reference period studied occurred in summer, with a higher frequency in the Mediterranean Sea than in the Atlantic Ocean. In fact, jellyfish sightings in the Andalusian region were more common on the coasts of the Mediterranean Sea than on the coasts of the Atlantic Ocean. At the same time, sightings were more frequent in bays, inlets, and high coasts with the presence of coves. These factors could be related to the fact that these geographical accidents present favorable conditions for the concentration of jellyfish swarms (Zavodnik 1987). Finally, we also found a rebound in sightings of jellyfish and other gelatinous organisms in urban and tourist centers. Beach users usually report most observations, who are often concentrated in urbanized tourist areas. In any case, the information provided by the citizens can be used to estimate onshore jellyfish arrivals (Gutiérrez-Estrada et al. 2021).

The mapping of jellyfish sightings by using GIS showed a hot spot—defined as an area of maximum concentration of jellyfish—at the confluence of the eastern Costa del Sol (province of Malaga) and the Tropical Coast (province of Granada), a strip in which the factors mentioned above are present. Among the main species sighted, *Pelagia noctiluca* stood out, especially on the Mediterranean coast, which agrees with the knowledge of this eminently Mediterranean species (Mariottini 2008). Likewise, we contrasted the fact that this species appears in aggregate form clusters in certain areas (Zavodnik 1987), an aspect that suggests the existence of spatial autocorrelation in the phenomenon. Second, but a significant distance from the first species, the dangerous *Physalia physalis* (Stein et al. 1989) sightings stood out, more

Table 2 Geographical distribution of jellyfish sightings

Municipality	Observations	%	Province	Sea basin
Almuñécar	300	15.71	Granada	Mediterranean Sea
Motril	109	5.71	Granada	Mediterranean Sea
Almería	99	5.18	Almería	Mediterranean Sea
Algeciras	84	4.4	Cádiz	Mediterranean Sea
San Roque	79	4.14	Cádiz	Mediterranean Sea
Cádiz	78	4.08	Cádiz	Atlantic Ocean
Níjar	78	4.08	Almería	Mediterranean Sea
Málaga	76	3.98	Málaga	Mediterranean Sea
Roquetas de Mar	69	3.61	Almería	Mediterranean Sea
Marbella	69	3.61	Málaga	Mediterranean Sea
Nerja	69	3.61	Málaga	Mediterranean Sea
Vélez-Málaga	59	3.09	Málaga	Mediterranean Sea
Puerto Real	58	3.04	Cádiz	Atlantic Ocean
La Línea de la Concepción	50	2.62	Cádiz	Mediterranean Sea
Tarifa	44	2.3	Cádiz	Atlantic Ocean
El Ejido	43	2.25	Almería	Mediterranean Sea
Fuengirola	38	1.99	Málaga	Mediterranean Sea
Rincón de la Victoria	34	1.78	Málaga	Mediterranean Sea
Benalmádena	27	1.41	Málaga	Mediterranean Sea
Torremolinos	27	1.41	Málaga	Mediterranean Sea
Gualchos	26	1.36	Granada	Mediterranean Sea
Almonte	25	1.31	Huelva	Atlantic Ocean
Mijas	25	1.31	Málaga	Mediterranean Sea
Torrox	25	1.31	Málaga	Mediterranean Sea
Ayamonte	24	1.26	Huelva	Atlantic Ocean
Cuevas del Almanzora	23	1.2	Almería	Mediterranean Sea
Manilva	22	1.15	Málaga	Mediterranean Sea
Enix	18	0.94	Almería	Mediterranean Sea
Albuñol	18	0.94	Granada	Mediterranean Sea
Barbate	17	0.89	Cádiz	Atlantic Ocean
Polopos	17	0.89	Granada	Mediterranean Sea
Adra	15	0.79	Almería	Mediterranean Sea
Salobreña	15	0.79	Granada	Mediterranean Sea
Vera	14	0.73	Almería	Mediterranean Sea
San Fernando	13	0.68	Cádiz	Atlantic Ocean
Huelva	12	0.63	Huelva	Atlantic Ocean

(continued)

Table 2 (continued)

Municipality	Observations	%	Province	Sea basin
Estepona	12	0.63	Málaga	Mediterranean Sea
Sorvilán	11	0.58	Granada	Mediterranean Sea
El Puerto de Santa María	8	0.42	Cádiz	Atlantic Ocean
Palos de la Frontera	8	0.42	Huelva	Atlantic Ocean
Carboneras	8	0.42	Almería	Mediterranean Sea
Chiclana de la Frontera	7	0.37	Cádiz	Atlantic Ocean
Conil de la Frontera	6	0.31	Cádiz	Atlantic Ocean
Isla Cristina	6	0.31	Huelva	Atlantic Ocean
Vejer de la Frontera	5	0.26	Cádiz	Mediterranean Sea
Rubite	5	0.26	Granada	Mediterranean Sea
Chipiona	4	0.21	Cádiz	Atlantic Ocean
Lepe	4	0.21	Huelva	Atlantic Ocean
Garrucha	4	0.21	Almería	Mediterranean Sea
Pulpí	4	0.21	Almería	Mediterranean Sea
Punta Umbría	3	0.16	Huelva	Atlantic Ocean
Mojácar	3	0.16	Almería	Mediterranean Sea
Algarrobo	3	0.16	Málaga	Mediterranean Sea
Casares	3	0.16	Málaga	Mediterranean Sea
Los Barrios	2	0.1	Cádiz	Mediterranean Sea
Lújar	2	0.1	Granada	Mediterranean Sea
Rota	1	0.05	Cádiz	Atlantic Ocean
Sanlúcar de Barrameda	1	0.05	Cádiz	Atlantic Ocean
Balanegra	1	0.05	Almería	Mediterranean Sea
Moguer	0	0	Huelva	Atlantic Ocean

Source own elaboration based on Rubio Gómez and Gutiérrez-Hernández (2020)

in the Atlantic than in the Mediterranean. However, according to our data, there is no way that we could speak unquestionably of a frequent. As we compared findings by consulting the data on rainfall, its presence seems to be related to the weather during the fall and winter months, especially with the recurrence of Atlantic storms. This circumstance has also been highlighted by Prieto et al. (2015).

Bordehore et al. (2016) have characterized our beaches as presenting a low risk concerning the severity of the stings caused by jellyfish, especially with the lower number of deaths caused by these than those produced in other coastal regions. However, we think that considering the typology of the main gelatinous organisms present on our coasts and whose sting has medium–high toxicity (*Pelagia noctiluca*) and high (*Physalia physalis*), a more comprehensive characterization of the risk, exposure, and danger should be reconsidered. In this sense,

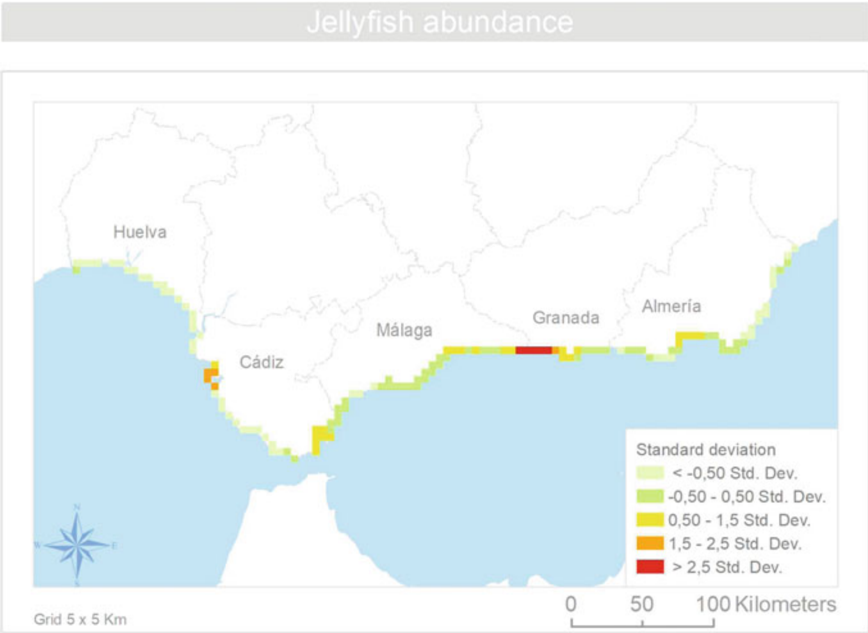

Fig. 8 Spatial distribution of jellyfish sightings. *Source* own elaboration

Ruiz-Frau (2022) concludes that coastal administrations should consider implementing preventive management plans to promote a sense of safety among tourists and residents alike. Furthermore, according to Crowley-Cyr et al. (2022), jellyfish-associated risk communications can influence people's risk perceptions—but not change their travel plans sufficiently.

Citizen science has contributed to monitoring biodiversity data on marine geography. Nevertheless, according to Arazy and Malkinson (2021), the potential of unstructured citizen science to monitor can result in biases in the aggregate database. These biases frequently can distort the effects under study, violating the reproducibility of the research and potentially leading to incorrect conclusions (Zvereva and Kozlov 2021). In either case, we think of a systematic methodology that jointly evaluates factors such as the dangerousness of species, the frequency of sightings, patterns of distribution, and concentration in space and time. Additionally, levels of occupancy of bathers on the coast should also be evaluated, and the unequal coverage of health and civil protection services on each beach.

Conclusions

In this chapter, we analyzed the sightings of jellyfish and other gelatinous organisms on the southern coasts of the Iberian Peninsula (Andalusia region, southern Spain) by using Geographic Information Systems (GIS). The jellyfish sightings are concentrated in summer and more frequently in the Mediterranean Sea: mainly between Costa del Sol (province of Malaga) and Costa Tropical (province of Granada), where *Pelagia noctiluca* is a jellyfish species most frequent. On the other hand, sightings are less frequent in the waters of the Atlantic Ocean. These observations include *Physalia physalis* (siphonophore), which occur more episodically during spring. According to the challenges of Marine Geography and the Sustainable Development Goals, we conclude that mapping jellyfish sightings can contribute to integrated coastal management regarding human activities and environmental issues.

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SDG 15. Protect, Restore, and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification, and Halt and Reverse Land Degradation and Halt Biodiversity Loss

Using the European CORINE Land Cover Database: A 2011–2021 Specific Review

Marta Gallardo and David Cocero

Abstract Land use and land cover changes (LULCC) are social, climatic and ecological changes that take place at multiple spatial and time scales. The study of these changes offers us a better understanding of the evolution of the territory and the changes that take place in its natural and cultural values. In Europe, the CORINE Land Cover (CLC) database is crucially important for monitoring these changes. As of today, it includes different maps of the land uses and covers in up to 39 countries, drawn in a standardized way. Within the context of the Sustainable Development Goals proposed by United Nations Agenda 2030 on Life on Earth, CORINE can provide essential information for a full understanding of the current situation of Goal 15 (Life on Land) so as to facilitate the design of sustainable policies for spatial planning and organization. In this paper, we perform a bibliographical review of the use of the CLC database. On the basis of qualitative and quantitative analyses, we analyse 77 publications indexed in the Web of Science Core Collection, published between 2011 and 2021, which include the word "CORINE" in the title. We observe increasing interest in the use of the CLC as a means of tracking the LULCC that have taken place and their impact on environmental issues such as deforestation, the pressures on protected natural areas and the soil erosion risk, among others. Other researchers analyse the CLC itself, assessing its accuracy and applicability with other sources and databases. Most of the papers refer to the maps for the years 2000 and 2006, using Level 3 of the thematic legend to study particular issues or dynamics at a local level. As regards the location of the institutions that use the CLC, those situated in Spain, Poland and Romania stand out. There were few links between the authors of these publications.

This work was supported by the Project INCERTIMAPS PGC2018-100770-B-100, funded by the Spanish Ministry of Science, Innovation and Universities and the Feder European Regional Development Fund and by Ayudas a Investigadores Tempranos UNED-SANTANDER 2022.

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_15

Keywords CORINE land cover · Europe · Review · Sustainable development goals · SDG 15

Introduction

Human beings depend on the Earth for our sustenance and survival. Plants provide approximately 80% of human foodstuffs, and agriculture is therefore a very important economic resource for many countries. In addition, 30% of the land surface is covered by forests, which serve as a habitat for millions of species and provide an essential source of clean air and water (United Nations 2022). Land use and land cover changes (LULCC), brought about above all by human action, are occurring increasingly rapidly, with direct consequences on climate change, biodiversity and ecosystem services (Eitelberg et al. 2016). Ellis (2010) defines land cover change as any alteration in vegetation, water or soil cover and land use change as an adjustment in human activity, related with changes in agriculture, forests, pastures or urban development. In the coming decades, humans are expected to continue to change the ways in which land is used, in response to pressure from environmental degradation and a growing demand for food, animal feed, biofuels and raw materials (De Jong et al. 2021). In this context, the study of LULCC is an effective way of revealing the interactive mechanism between human activities and the natural environment (He et al. 2022). The modelling of these changes and a greater knowledge of their implications are necessary when it comes to drawing up effective planning and environmental strategies (Gallardo and Martínez-Vega 2016).

Sustainable Development Goal number 15 (Goal 15 or SDG 15) refers to "Life on Land" and is one of the 17 Sustainable Development Goals (SDGs) established by the United Nations in 2015. The objective of SDG 15 is to "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (United Nations 2022). Conserving and restoring the use of terrestrial ecosystems, such as forests, wetlands, drylands and mountains, and halting deforestation are of vital importance for mitigating the impact of climate change. Urgent steps must therefore be taken to reduce the loss of natural habitats and biodiversity, which are part of our common heritage (United Nations 2022).

Within SDG 15, there are 12 targets which are considered critical for achieving the main goals. The third of these targets is as follows: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" (UN Women 2022). The following indicator has been proposed as a means of assessing the current status of this target: "Proportion of land that is degraded over total land area". Three other sub-indicators can also be used by the different countries for monitoring purposes and to quantify the proportion of degraded land (United Nations 2017): (a) land cover; (b) land productivity; (c) carbon stocks above and below ground.

Although the land cover products available at a regional scale do not provide the right geographic framework to be considered ideal for the study of Target 15, the use of regional products at a national scale may offer advantages as a way of better characterizing the most important, most specific land covers in each country. One of these regional products is the CORINE Land Cover database (CLC), which covers the 27 Member States of the European Union and various other European countries. These data are based principally on the visual interpretation of satellite images from the Landsat, SPOT and Sentinel programmes. The production is decentralized at the national level in order to create a uniform land use and land cover map of Europe, which provides a complete and consistent set of data for the whole of Europe, in vector format. The CLC database is available for the years 1990, 2000, 2006, 2012 and 2018 (Sims et al. 2021).

In this regard, over more than 20 years, numerous studies have been carried out using this database as a primary or secondary source. In this chapter, we perform a specific bibliometric analysis, detailing the publications listed in the Web of Science (WoS) that make use of the CLC database over the last 11 years. Bibliometric methods have been used to perform a quantitative analysis of written publications, based on the identification of the corpus of literature within a given subject area (Ellegaard and Wallin 2015). Meta-analyses are able to handle large amounts of literature and can provide a summary of a particular field and the heterogeneity of existing studies. In addition, systematic literature reviews tend to include between tens and low hundreds of papers for review and are suitable for fairly restricted or niche research areas (Donthu et al. 2021). In recent years, these methods have become increasingly popular, and various software programmes have been developed to facilitate analysis (Grant and Booth 2009).

We summarize the main characteristics of these studies and how they use CLC, detailing: (a) their trajectory; (b) the research fields within which they fall; (c) where they publish; (d) the number of citations they receive; (e) the subjects they explore; (f) the most commonly used words; (g) the institutions to which the authors belong; and (h) the relations between them. When analysing how they used the CLC, we looked at the cartographic base(s) they used (what year), the level of thematic legend, the study areas and its applications and the relationship with the SDG 15 objective.

CORINE Land Cover Database

The Coordination of Information of the Environment (CORINE) Land Cover programme was created by a resolution of the Council of Ministers of the European Union (CE/338/85), dated 27 June 1985, by virtue of which a decision was taken to embark on "an experimental project for gathering, coordinating and ensuring the consistency of information on the state of the environment and natural resources in the Community" (Pérez Martín et al. 2020).

It provides information about land cover, land use and land cover/use changes over time. Its applications include spatial management, forestry management, water management, emergency management, etc. Its main characteristics are: It is produced by the member states and is coordinated by the European Environment Agency; it is a standard, homogenous product covering almost all of Europe, using a vector information system with a single polygon layer; it has five versions: 1990, 2000, 2006, 2012 and 2018, that were produced by assisted photograph interpretation of reference images from Landsat 5 or by a generalization of finer national LULC database (1990), Landsat 7 (2000), Spot 4/5 and IRS (2006), IRS and Rapid Eye (2012) and Sentinel 2 (2018) satellites; it has a spatial scale of 1:100.000 and a minimum polygon unit of 25 ha—in the case of change polygons, 5 ha-; it is economically sustainable and periodically updated (IGN 2018; Pérez et al. 2020).

The CLC hierarchical nomenclature contains 44 classes divided into three levels of thematic detail. These classes were defined via the continuous, joint efforts of experts from different European countries who sought to describe all the landscapes existing in Europe today. The first level contains five large groups of classes: artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands and water bodies. These classes are subdivided into a second and third level of detail, and each CLC polygon must be classified at the maximum level of detail. Each class is identified with a three-digit code: the first digit denotes the first level category to which the class belongs, the second refers to the second level, and the third the third level (IGN 2018). This variety of land use/land cover classes and the fact that there are several maps from different years facilitate environmental decision-making, the quantification of loss of natural environments, deforestation and fires, the obtaining of urban expansion variables, the identification of areas that require protection, etc., at a European level. Key issues to monitor and understand if the SDG 15 is to be archived.

The future of the CORINE Land Cover project is guaranteed by the European Union, and the Copernicus Programme is currently developing new methodologies and new CLC products that can satisfy current needs. These revolve essentially around providing greater geometric and thematic detail.

Bibliographic Reviews Relating to Land Use/Land Cover Change

There is increasing interest in the land use and land cover changes (LULCC) that have taken place in the past and in modelling possible changes that may take place in future. It is also important to assess the implications that such changes will have on the environment and on society at global, regional and local levels. In association with the increase in studies of this kind, the development of software programmes and the increasing availability of data online, there has also been an increase in systematic reviews and meta-studies relating to LULCC, the factors and the forces behind them and their implications and consequences, in order to highlight the advances and the opportunities for the future offered by these studies. To cite just a few examples, Agarwal et al. (2002) carried out a review of 136 papers to analyse different types of land use change models and explore their functionality. Lambin et al. (2003) observed the increasing complexity in the development of LULCC models. De Jong et al. (2021) analysed 62 case studies in order to report on the conditions and causes of land use change conflict. Gomes et al. (2021) detailed 79 papers that related LULC futures with their impact on terrestrial ecosystem services. Nedd et al. (2021) carried out a review of 146 articles and meta-studies, including definitions of LULCC and its classification systems. Or He et al. (2022) detailed the research conducted between 1990 and 2018 on LULCC summarizing its main characteristics and the progress that has been made.

Specific reviews applied to a specific geographic area can be found in Pham et al. (2015), who analysed 17 studies of LULCC in northern and border upland Vietnam; in Fernández and Corbelle (2017), who conducted a meta-analysis of 47 studies by Spanish and Portuguese researchers on LULCC in the Iberian Peninsula. For their part, De Alba-Rosano et al. (2020) analysed 196 papers that referred to this topic in Mexico. Ruiz and Sanz-Sánchez (2020) observed the effects and interactions of LULCC in the Mediterranean basin detailed in 23 studies; in the same field but focusing on Euro-Mediterranean mountains, Jiménez-Olivencia et al. (2021) observed the dynamics in 53 case studies in relation with land use changes, their causal factors and their effects on the landscape.

There are also a number of reviews addressing very specific topics, such as those by Méndez-Rojas et al. (2021), who analysed different studies in order to observe the influence of land use change on rove beetle diversity, or Sasmito et al. (2019), who observed the effect of LULCC on mangrove blue carbon stocks.

In relation with CORINE, Bielecka and Jenerowicz (2019) published a review of 873 documents found on the Web of Science (WoS) between 1985 and 2019 that used this database in their research in order to highlight the intellectual and cognitive structure of its application.

Methods

We performed a search of the Web of Science (WoS) Core Collection for papers published in the last eleven years (between 1 January 2011 and 31 December 2021), in order to analyse documents available in the last decade that can use both older (1990) and recent (2018) CLC databases. First, we analysed the temporal trend, how many documents where published and the research fields of papers that included the word "CORINE" (TS = (corine)) or "CORINE Land Cover" (TS = corine AND land AND cover). Due to the limited time available for this study, we decided to restrict our selection to publications that included just the word "CORINE" (TS = (corine)) in their title. This was based on the assumption that if the authors decided to use this word in the title, it was because the CORINE Land Cover database played an important role in their research.

This search was conducted on 14 January 2022, and a total of 79 references were obtained. Two of these references dealt with a completely unrelated topic and were therefore eliminated, leaving a total of 77 papers. These included articles, book chapters and proceedings (see Appendix).

By means of both quantitative and qualitative analyses and following the Search, Appraisal, Synthesis and Analysis (SALSA) analytical framework (Samnani et al. 2017), we analysed who the authors of these papers were and the institutions to which they belonged, observing the possible relations between them. We also observed in which journals they were published and the fields of research to which most of these publications belonged. Other variables included the most frequently used words. We also observed the number of times these articles had been cited in other research publications and the relationships between the citations and the authors.

As regards their use of the CLC database, we analysed the papers contents to find out which version(s) of CORINE (dates) and which thematic scale (hierarchical level of their legend) they used. We also examined the geographical focus of their analyses. Finally, we detailed how they use this cartography and the main topics discussed.

For these purposes, we used the Zotero, Atlas.ti, Excel and VOSviewer software programmes. Zotero was used to organize and manage the bibliography. Excel enabled us to make simple calculations to obtain quantitative data about the publications and how they use CLC. Atlas.ti was used to analyse the information qualitatively, obtaining word clouds of the words appearing, in this case, in the abstracts of these publications. Lastly, VOSviewer was used to observe the relations between the different authors, their citations and co-citations and the institutions at which they work; the maps were created on the basis of bibliographic data, for which we used the doi of the publications. Forty-three of the 77 documents were analysed in VOSviewer, choosing a minimum of one or two publications per author. A minimum of 10 publications per author was applied in the analysis of the citations. The data were entered into the software using crossref, so authors' names and sources may not have a consistent format and may not have been harmonized. In this sense, results of the analyses carried out with the VOSViewer should be interpreted with caution.

Results

Table 1 shows the number of references found in this database over the study period, using the keyword "CORINE" (TS = corine) or the keywords "CORINE Land Cover" (TS = corine AND land AND cover) and after broadening the search, going beyond just the title of the publication, to include papers that mention them anywhere in the text or in the abstract. This produced over 800 publications with the word "CORINE" over the last eleven years. This fell to almost 750 with the search for "CORINE Land Cover". About 720 papers contained the word CORINE in the abstract, while 642 contained the words CORINE Land Cover.

The only filtered results were those relating to the search for the word "CORINE" in the title. The broader searches were not filtered, so the results obtained may include

Table 1 Number of manuscripts published between 2011 and 2021 in the WoS according to the keyword or keywords selected and the place where they appear

Keyword	Place	Nº publications
CORINE	Whole article	821
	Abstract	720
	Title	79
CORINE Land Cover	Whole article	747
	Abstract	642
	Title	57

Source the authors

references to CORINE or to CORINE Land Cover that are not related with the topic of land uses and covers.

As regards the research fields within which these publications with the word CORINE in the title can be classified, we should highlight Environmental Sciences Ecology, with 84 publications, Biodiversity Conservation with 63 and Geography with 50 (Fig. 1).

If we broaden the time period for our search for "CORINE" in the title of the papers to include the whole period covered by the CLC database, we obtain 121 publications related with this topic. In Fig. 2, we can see how interest in the use of the CLC database

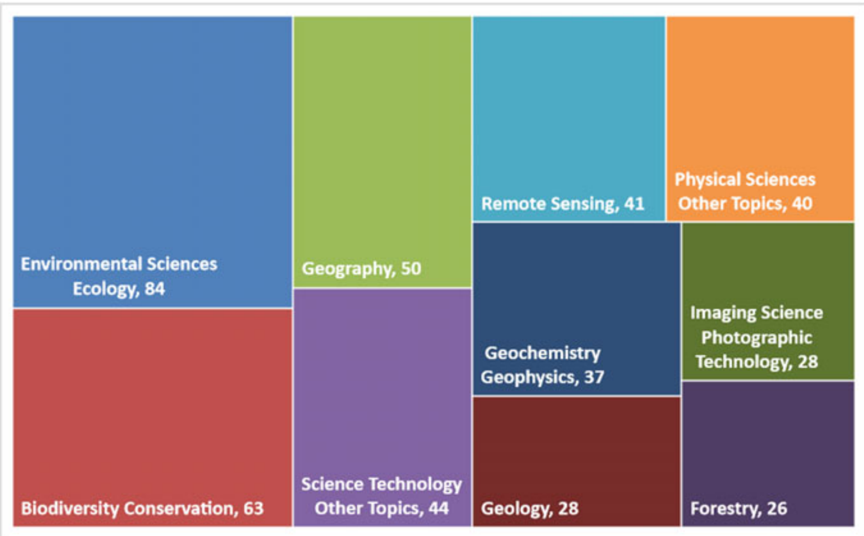

Fig. 1 Research fields and number of publications available in the WoS that contain the word "CORINE" in the title published between 2011 and 2021. The size of the rectangles is proportional to the number of publications. Drawn up by the authors on the basis of data from the WOS Core Collection

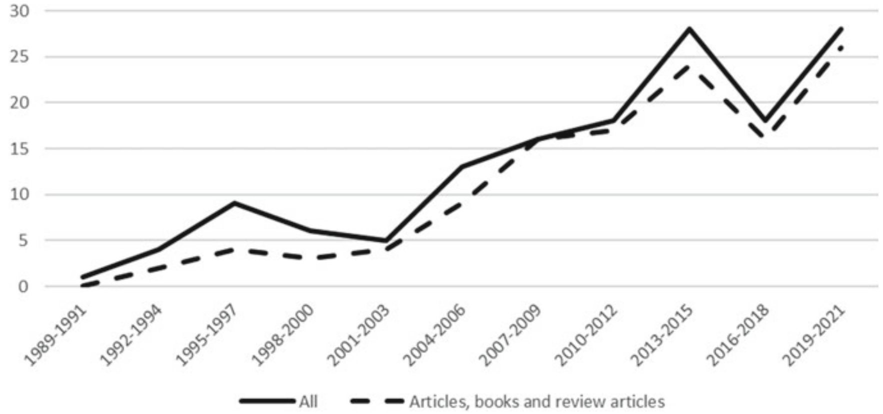

Fig. 2 Number of publications available in the WoS with the word "CORINE" in the title by time period. The total includes meeting abstracts and other unspecified documents. Drawn up by the authors. Data from the WOS Core Collection

has grown, especially from 2004 and 2013, reaching 26 publications between 2019 and 2021 (28 if we include meeting abstracts and unspecified documents).

The period analysed in this research runs from 2011 to 2021 in which 77 articles, books and review articles were published. This positive trend, with a slight fall between 2016 and 2018, is related with advances in the development of the CLC cartography, which made more data available and made it easier, for example, to make comparisons over time.

As regards the 77 publications analysed in this research, most of these studies were papers published in scientific journals. There were only two book chapters and three proceedings, all of which were indexed in the WoS. Table 2 shows the first ten journals in which most articles were published. At the top of this list is the journal Remote Sensing, which in 2020 published a special issue entitled "CORINE Land Cover System: Limits and challenges for territorial studies and planning". Forty-three journals published just one article.

As regards the individual words that were most frequently used in the abstracts for these publications, we should highlight "land", "cover", "CORINE" and "data" (Fig. 3), but there were also many others related with the sources (satellite, Sentinel, Landsat), the methods (mapping, model, aggregation, comparison, simulation, accuracy), their applicability (erosion, soil, species), land covers/uses (forest, urban, agricultural, water, natural), places (watershed, habitat) or consequences (diversity, richness, conservation, management).

Table 2 Journals and number of publications

Journal	Publisher	Impact factor (JCR)	Publications
Remote Sensing	MDPI	4.848	14
International Journal of Applied Earth Observation and Geoinformation	Elsevier	5.933	6
Atmospheric Research	Elsevier	5.369	2
Carpathian Journal of Earth and Environmental Sciences	Carpathian Association of Environment and Earth Sciences	0.162	2
International Journal of Remote Sensing	Taylor & Francis	3.151	2
Journal of Maps	Taylor & Francis	2.709	2
Land	MDPI	3.398	2
Present Environment and Sustainable Development	PESD	ESCI	2
Urbanism Architecture Constructions	Nird Urban-Incerc	ESCI	2
Other	–	–	43

It also shows the publisher of the journal and its impact factor in the Journal Citation Report in 2020
The authors

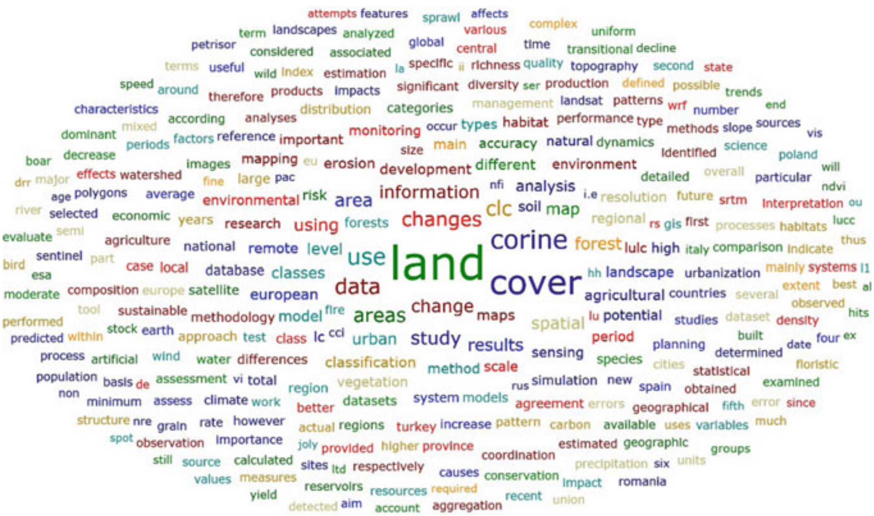

Fig. 3 Word cloud of the words found in the abstracts of the publications. Drawn up by the authors

The Authors

There were weak relations between the authors of the different publications. There were 8 sole-authored publications, representing 10% of the total. Most of the publications had either two or three authors (42%), while 26% had four or five authors. About 22% had more than five authors. As regards the number of affiliations, the largest groups were the manuscripts with just one affiliation (38%) and those with two or three affiliations (49%), while the manuscripts with four or five different affiliations represented just 10% of the total and those with more than five affiliations just 3%. Geographically speaking, their affiliation was very local in that 70% of the manuscripts were written by authors belonging to institutions from the same country, and the remaining 30% were by authors located in two or three different countries.

As regards the relations between their places of affiliation, if we analyse the 43 documents selected in VOSViewer using a minimum of one publication per author, we observed that there were 20 institutions and that the largest network was made up of just five of them (Fig. 4): the Department of Ecology of the University of Alicante (Spain), the INIA (Spain), the Department of Biology and Geology, Physics and Inorganic Chemistry of the University Rey Juan Carlos (Spain), the Group on Ecology and Forest Restoration of the University of Alcalá (Spain) and the Department of Geography and the Environment of the University of Aberdeen (United Kingdom). There were also two other smaller clusters each made up of three institutions: the first contained the Faculty of Science of the University of Zagreb (Croatia), the Croatian Natural History Museum and the National Centre for External Evaluation of Education (Croatia); the second was made up of the Department of Biology of the University of Aveiro (Portugal), the Department of Zoology of the University of Salamanca (Spain) and the INIA (Spain).

The next stage was to analyse the relations between authors and co-authors. In total, there were 150 authors, who together formed 35 different clusters. The largest network was made up of 9 interconnected people: six researchers from the University of Warsaw, Poland (Ahmed H Al-Sulttani, Anca Dabija, Marcin Kluczek, Marlena Kycko, Edwin Raczko and Bogdan Zagajewski) and three employees from the Cartographic and Geological Institute of Catalonia, Spain (Jordi Corbera, Lydia Pineda and Anna Tarda). When the search was restricted to authors who had published at least two articles, we obtained 4 clusters (Fig. 5), made up of: (a) D. Bălteanu, I. Grigorescu, G. Kucsicsa B. Mitrică and E. Popovici, all of whom belong to the Institute of Geography, Romanian Academy, Romania; (b) A. de Meij and J.F. Vinuesa, from Noveltis, France; (c) I. Cieślak and K. Szuniewicz, from the Faculty of Geodesy, Geospatial and Civil Engineering of the University of Warmia and Mazury (Poland); (d) and P. Śleszyński, from the Institute of Geography and Spatial Organization of the Polish Academy of Sciences (Poland).

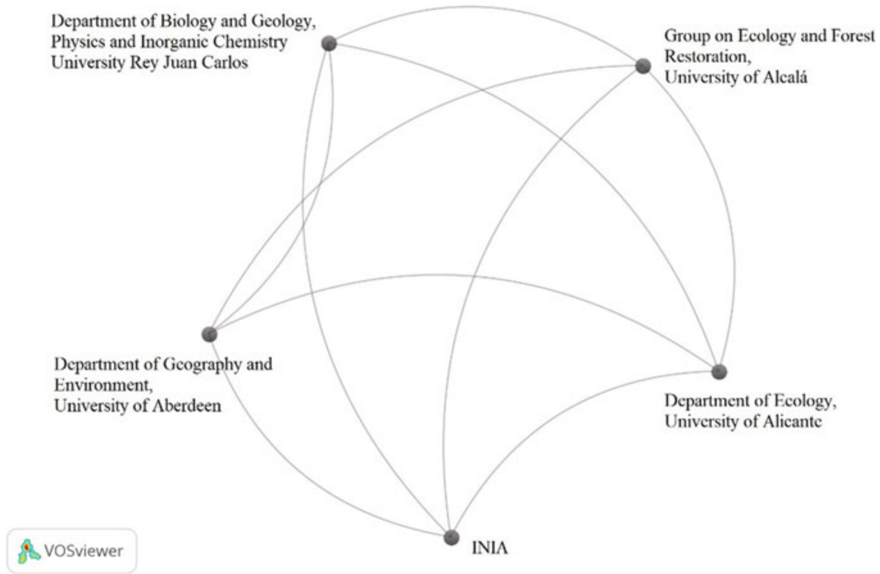

Fig. 4 Biggest cluster between organizations and co-authorship. Drawn up by the authors

Analysis of the Citations

As regards citations, these articles, book chapters and proceedings have so far been cited on 1152 occasions (1052 not including self-citations). Eight of the publications have never been cited. This gives an average per publication of 14.05 citations. The most cited publication is the book chapter by Büttner (2014) with a total of 89 citations, detailing the main characteristics of CLC, and how it has evolved over time with the production of the first three databases and their accuracies. This is followed by the article by Baltzer et al. (2015) with 87 citations, in which they demonstrate the validity of Sentinel-1A images for discriminating several CLC classes and monitoring cloud-covered regions. Perez-Hoyos et al. (2012) received 54 citations for an article that provides a methodology for comparing global land cover maps that allows for differences in the legend definitions, using CLC, GLC2000, MODIS land cover and GlobCover. The paper by Gallego et al. (2011) also received 54 citations, in which they compare the disaggregation methods used to produce a dasymetric population density grid of the EU, using CLC as ancillary information. Lastly, the fifth most cited publication (with 51 citations) was a paper by Díaz-Pacheco and Gutierrez (2014), in which the authors analysed the limitations of CLC for monitoring urban land use dynamics. Figure 6 shows the publications and citations on an annual basis over the period analysed. The maximum was achieved in 2021 in which 13 articles were published and 260 citations were received.

We then looked at the co-citations, in other words the citations within each article of any of the other articles analysed. If from the total of 803 authors (those who wrote

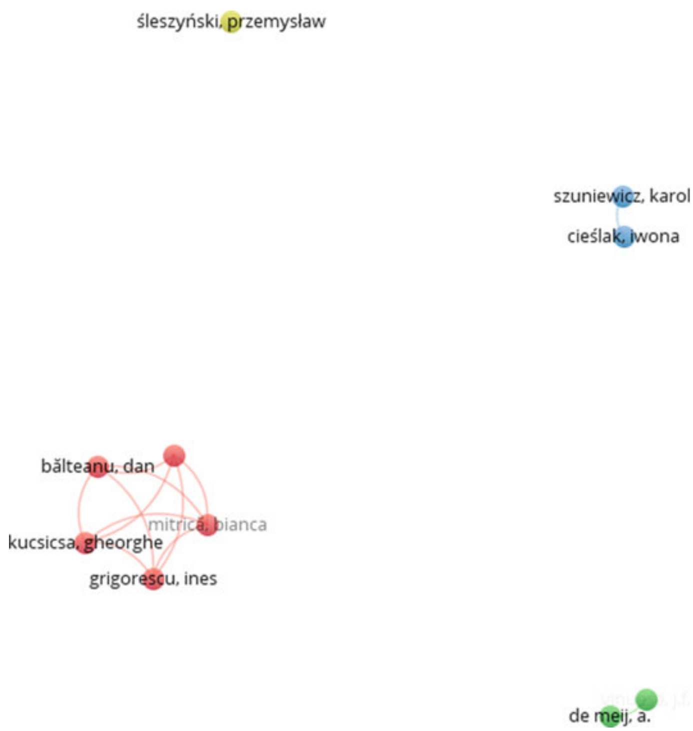

Fig. 5 Relation between authors and co-authors with a minimum of two documents per author. Drawn up by the authors

Fig. 6 Annual number of publications that contain CORINE in their title and the citations thereof over the period 2011–2021 WOS Core Collection

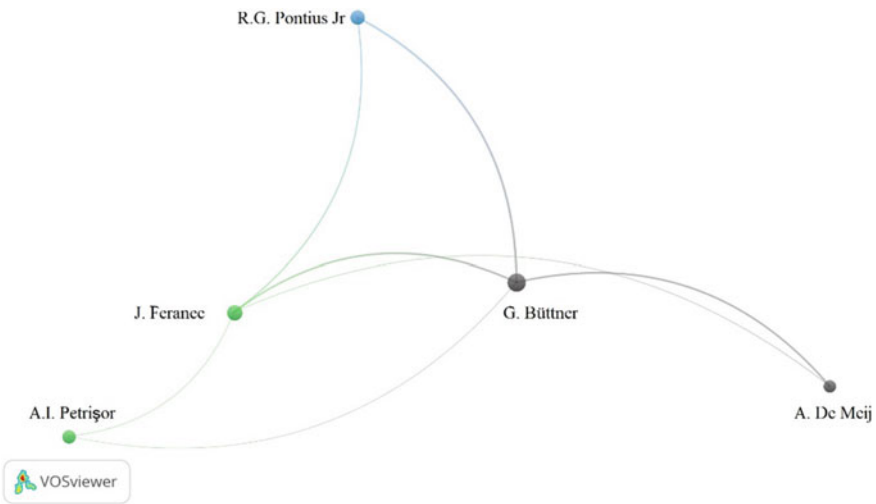

Fig. 7 Cluster between cited authors and co-citations. Drawn up by the authors

the articles plus those cited in the bibliography), we select those with 10 or more citations, we obtain a single cluster made up of three subclusters, as can be seen in Fig. 7.

This cluster is made up of R.G. Pontius Jr. (Clark University, USA), in blue; A. De Meij (Noveltis, France) and G. Büttner (European Environment Agency), in black; and J. Feranec (Slovak Academy of Sciences, Slovakia) and A.I. Petrişor (Ion Mincu University of Architecture and Urbanism, Romania), in green.

The Use of the CLC Database

A very wide range of topics are explored in these articles. These range from a detailed study of the characteristics of the CLC database to the production of its cartography or of more detailed maps based on this cartography. Figure 8 shows the topics analysed in these research studies. Many authors use the CLC database for LULCC and environmental changes. The second most frequently used topic focused on the accuracy of the database itself (including its thematic quality) or in comparison with other data sources on land use change at a global or local level (third topic). Lastly, a few publications centred on the production of its cartographic base and one article made a systematic review of the different applications of CLC.

More specially, the authors use the CLC to identify LULC changes, their patterns and causes, or to draw up predictive scenarios. They also use them to analyse deforestation, urban development and sprawl, green infrastructure, the dynamics in agricultural lands, pressures on Natura 2000 sites or to analyse the urban-rural gradient. They also examine CLC's potential for observing dynamics at a micro-scale or in

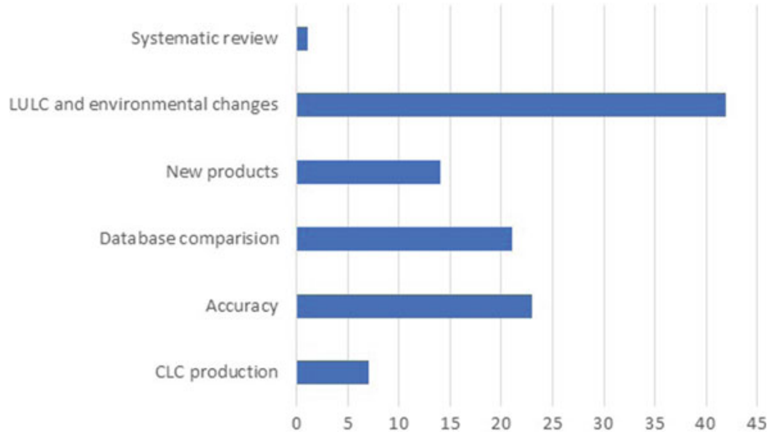

Fig. 8 Topics analysed by the authors. Drawn up by the authors

watersheds or for assessing soil erosion risk, the floristic composition, water quality or the capacity of CLC to separate vascular plant assemblages or to estimate and predict the richness of fauna communities. CLC has also been used to estimate soil organic carbon stocks, wildfire occurrence, potential vehicle speed and to predict food production. The authors were also interested in proposing new vegetation or fragmentation indices and new urban indicators and in assessing the applicability of CLC as a basis for climate simulations, population densities or for the Water Research and Forecasting (WRF) model. Monitoring of all these processes provides us indicators to analyse the progress made towards the achievement of the SDG 15, which aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forest, combat desertification, halt and reverse land degradation and halt biodiversity loss.

Other authors assess the accuracy of CLC via the aggregation of its thematic legend or by making comparisons with other cartographic databases or with products derived from satellite images, in order to evaluate their potential, their misclassifications, their limitations for monitoring certain land uses and covers or their discrepancies. These include Urban Atlas, GLG2000, Global Land Cover Characterization database (GLCC), LUCAS survey, ESA Climate Change Initiative on Land Cover (CCI-LC), ESA GlobCover and SIOSE or data from Sentinel, MODIS or Landsat images. They also made comparisons with LiDAR, Shuttle Radar Topography (STRM) sources and with national statistical databases and even field data photographs from platforms such as Flickr and Panoramio.

As regards the use of CLC maps, 56% of these studies used the maps for 2006 and 47% used those for the year 2000. These percentages were slightly lower when we looked at the maps for 1990 (26%), 2012 (25%) and the most recent one, 2018 (23%). It is important to bear in mind that 46% of the studies used more than one map; in other words, they made comparisons between the maps and observed the evolution of certain land covers/uses over time. In addition, the most frequently used hierarchal

Table 3 Number of publications according to the different thematic legends of CLC and the different versions of the database (years) used

Legend level	Number	Year	Number
CLC 1	14	1990	20
CLC 2	15	2000	36
CLC 3	51	2006	43
CLC 4 or 5	3	2015	19
Reclassification	30	2018	18

The authors

level was Level 3, which was used by 66% of the articles. This was followed by Level 2 and Level 1 with 19% and 18%, respectively, and lastly by Level 4, which was used in 4% of the articles. Once again, it is important to bear in mind that a single study may use various different thematic scales. Furthermore, in 30% of the studies, the authors carried out a reclassification of the categories, normally on the basis of CLC Level 3, so as to adjust them to the subject they were researching (Table 3).

In this sense, it is important to remember that 57% of the studies were made at a local scale, 29% at national and 10% regional. The countries which concentrated most of these studies were Poland and Romania with nine and eight studies, respectively, and Italy, Spain and Turkey with six studies each.

Discussion and Conclusions

Bearing in mind that three-quarters of the ice-free land surface is used or managed by humans and that many land systems have constrained future options, due to land use changes that crossed critical thresholds and created path dependence (Meyfroidt et al. 2022), the knowledge of LULCC and its drivers, impacts and responses are essential for achieving sustainable development and the SDGs, and in particular SDG 15. In this sense, cartographic databases developed according to standardized methods at different points in time, such as CLC, play an essential role in expanding our knowledge of these issues and monitoring past and future trajectories. To this end, there are various studies (Hinz et al. 2020; Cao et al. 2022) that focus on constructing future LULCC scenarios in relation with the SDGs in order to assess the trade-offs and their implications.

Our review focused on a Europe-centred cartography (CORINE). The bibliometric analysis of the 77 publications obtained in our search highlights the growing interest in the use of CLC in order to gain a clearer picture of land use and land cover change in different parts of Europe and its impact on different environmental issues. Most of the studies we analysed dealt with subjects such as urban growth and the reduction in agricultural land, while also displaying interest in the relation between these LULCC and soil erosion, their effects on flora and fauna dynamics and their impact on protected natural spaces. The accuracy and disagreement of CLC have also been assessed, as has its applicability with other LULC sources and databases or with climate models.

Most of these studies use the cartography for 2000 and 2006 and almost half of them used more than one time point. Over 60% of the studies used Level 3 of the thematic legend, and a third of them reclassified this legend in order to be able to carry out their analyses. Over half used CLC to make a local study, while almost a third worked at a national scale and only 10% at a regional scale.

As regards the journals in which they were published, we should highlight a special issue of Remote Sensing Journal. The second most popular journal was the Journal of Applied Earth Observation and Geoinformation. In most cases, the publications were written by two or three authors who work in one, two or three institutions in the same country. The relationship between the authors of these publications was in general quite weak.

The results obtained coincide with the bibliometric analyses and the systematic analyses conducted by other scholars (Gomes et al. 2021; He et al. 2022), who highlighted an upwards trend in publications in relation with LULCC studies. This is also evident in the review of CLC by Bielecka and Jenerowicz (2019) in which they highlight this trend. They also found similar results in terms of the main topics analysed (forest fragmentation, soil erosion and loss, agriculture, urbanization or accuracy), although differences can be observed in relation to the authors and their publications, as their article had a broader time spectrum (1989–2019) and analysed more publications than ours.

Our study has an obvious limitation in that we only selected articles with the word "CORINE" in the title. It also has a limited timeframe in that we selected the papers published in the last 11 years. Lastly, there is a limitation in the use of databases, as the search was restricted to the Web of Science Core Collection. If we were to widen the search to other databases such as Scopus or Google Scholar or if we were to extend the timeframe, different results might be obtained. We believe that a broader systematic review which encompasses other bibliographic databases and a longer timeframe is necessary in order to verify the interest and the use made by scientists of the CLC database. As we have previously stated, it is also important to make clear that the results of the analyses carried out with the VOSViewer should be interpreted with caution, in that as they were introduced with crossref the authors' names and sources may not have a consistent format and may not have been harmonized.

Finally, we want to point out that in our selection, there is lack of papers that focus on the use of CLC for policy development or land use, urban or environmental planning in order to offer ways to respond to these changes and challenges. The Sustainable Development Goals for 2030 can only be realized with effective policies, developed according to the specific assets, the cultural background, the resources and criticalities of each country (Bellantuono et al. 2022), and as De Wit and Verheye (2009) make clear, sustainable development approaches may only be put into practice if there is a political will to do so. Therefore, for the achievement of SDG 15, it is also necessary to strengthen the means of implementation and revitalize the multistakeholder and voluntary commitments specified in SDG 17.

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SDG 16. Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable, and Inclusive Institutions at All Levels

Achieving a Sustainable Future: The Geographical Centrality of UN SDG-16, Peace, Justice and Strong Institutions

Gerry O'Reilly

Abstract Embedded in the UN Sustainable Development Goals, No. 16 is vital in promoting inclusive societies with integrity at multiple scales. Foundational to geographical research is human-environmental relationships necessitating balancing rights and duties rooted in good citizenship. Such research informs policy formulation, institution building and education. In development, technology is central to innovation, but appropriate policies need to be mediated between state and populace in order to legislate for workable sustainability. Extreme dangers range from global warming to human rights abuse, armed conflict and excessive power of transnational corporations. Geopolitical perspectives provide key concepts in internal and external functioning of states upon which the international system of law is based as exemplified by UN and multilateralist approaches. The EU reinforces this promoting human rights, democracy, rule of law and sustainability. Education is essential in raising awareness of sustainable development and the pivotal role of SDG-16.

Keywords SDG-16 · Peace · Justice · Institutions · Human rights · Geopolitics · Education

Introduction: UN Sustainable Development Goal 16

This chapter appraises SDG-16, rule of law at varying scales and concepts in Geography, the human-environment nexus—ecology, economy and society-culture. Theory and contexts are explored including various schools of political economy and variables in SDG-16, alongside the UN and governance. The centrality of core EU values is highlighted in the face of challenges. The realities of humanitarian emergencies are elucidated with reference to SDG-16. Hence, the crucial role of Geography and education in understanding and application of the SDGs is considered with contrasting samples of geographical education projects.

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_16

Embedded in UN Sustainable Development Goals (SDGs) is No. 16—Peace, Justice and Strong Institutions so vital in promoting peaceful inclusive societies with justice for all and building accountable institutions at multiple scales. This is premised on the rule of law ensuring equal access to justice (Milton 2021; Blind 2020; Bali Swain 2017; UN Sustainable Development Goal Report SDG-16 2020).

Kernel to this rule of law, furthering concepts that are based on precedents, balancing power within societies and state systems is government legitimated by protecting its citizens in return for loyalty rooted in social contracts. When this breaks down, violence, government/regime change or state collapse ensues.

Rule of law embraces:

- Equality before the law
- Checks and balances on the use of power
- Rights of the accused and victims
- Presumption of innocence
- Independence of the judiciary
- Right to assemble
- Freedom of speech
- Access to justice
- Knowing the law.

At wider scales, in pursuance of peace so as to avoid armed conflict and limit social-economic and environmental damage, intergovernmental organization authority institutions like the UN attempt to create and implement international law including conventions, i.e. voluntarily signed and ratified by state representatives. However, this poses dilemmas for authoritarian regimes, characterized by rejection of political plurality, use of strong central power and/or military dominance to preserve their status quo, detracting from an ethical rule of law, separation of powers and democratic voting. In 2022, extreme examples included Myanmar, North Korea, Syria, DR Congo and actions of the Putin regime in Russia, including the invasion of Ukraine. The rule of law must be fair and equitable within states and between them and be experienced as such by citizens. Historically, Europe has witnessed the non-sustainable effects of totalitarian regimes. This has been a driving force underlying the creation of the EEC/EU with its core value policies opposing tyranny, oligarchy and human rights abuse. The EU supports the UN in promoting the SDGs (IISD 2021; UN and the Rule of Law 2021; UN 2020; Consuegra 2020).

Foundational Geographical Research

In development processes, technology is central to innovation and diffusion, but appropriate policies must be mediated between governance power structures and citizens in order to legislate for workable sustainability. The antithesis of this is pollution, global warming, major socio-economic inequalities, human rights abuses, armed conflict, excessive power of transnational corporations and criminal cartels.

Hence, geopolitics provides key concepts in the internal and external functioning of states upon which the architecture of the international system is based as with the UN. Likewise, the EU embodies concepts of organization, promoting human rights, democracy, equality and rule of law. Here, education is crucial in raising awareness of sustainable development enmeshed with SDG-16.

- Peace—societal harmony including freedom from state or international violence and non-sustainable practices.
- Justice—recognition of the citizen's endowments and entitlements embedded in human and civil rights with equality, i.e. a just rule of law.
- Institutions—with reasonable structures that empower citizens' actions in a sustainable way for themselves and their future children (Singer-Brodowski et al. 2019).

In 1949, a milestone in the development narrative was reached at the UN, when US President Harry Truman stated a key policy objective was: to make the benefits of scientific and industrial progress available for the improvement and growth of under-developed areas. He referenced people worldwide living in conditions of misery, food shortage and disease, highlighting that poverty is a handicap but also a threat. He underlined that humanity possesses the knowledge and skill to relieve suffering through development of industry and science and that knowledge is constantly growing (Macekura 2013). Truman rebuffed allegations that this was a colonial venture, especially in contexts of the Cold War (1945–1989) and decolonization. Whatever accusations, this was a landmark in the modernity-development trajectory. In 1992, the UN Conference on Environment and Development (UNCED), or Rio Earth Summit (Agenda 21), was a wakeup call for states to cooperate internationally on development and 'sustainability' that was too big for individual member countries to handle and collaboration with grassroots NGOs was prioritized. This fed into the Millennium Development Goals (2000–2015) and pursuant SDGs (2015–2030) (Saner et al. 2019).

Theory, Concepts and Contexts

Central to theory and functionality of applied frameworks targeting sustainability is the UN SDG-16 promoting inclusive societies, justice, accountability and comprehensiveness concerning local to global institutions. Violence and poverty are the antithesis of development, i.e. long-lasting positive change. Conflict can be due to material, and/or non-physical or existential causes, ranging from competition for land, water, food, shelter and minerals to extreme ideological or cultural belief systems. The geographical sciences contribute greatly to progressing the SDGs, being based on investigating human-environmental relationships within specific areas, regions and globally searching for cartographic patterns and explanations highlighting areal differentiation underpinned by categorization methods. This was revolutionized by GIS layering techniques and Earth System Science (ESS); for instance, monitoring interactions between the anthroposphere and other geospheres, e.g. atmosphere and hydrosphere. Organizations promoting such research and its diffusion in education include EUROGEO (European Association of Geographers 2022; Koutsopoulos et al. 2019).

Human existence is underlain by nexus between the ecological (web of life), economic (making a living) and society-culture value system that take place in specific geographical scales. Thus, the evolution of social contracts, customary law, citizenship and civilizations aims to avoid violent conflict. Whatever definition is used for development, the kernel remains to eradicate poverty or lack of means necessary to meet basic personal and social needs. In 2021, one in ten people were living in extreme poverty globally. Relative poverty exists within and between societies and countries whether in the EU or Global South. Poverty can be situational, generational, rural, urban and so forth. SDG-1 aims to end poverty in all forms everywhere, but poverty is multifaceted and multidimensional. Hence, by its nature, development is a power issue. Cognizance must remain that there are differences between needs, wants, consumerism and accumulation (World Bank 2020, 2021; Brookings 2021).

Few development commentators would argue that industrialization since the eighteenth century has not been key to the benefits of modernity. Where they disagree is how profits should be spent, and costs to society and environment, as articulated by different schools of political economy:

(i) Capitalism and its iterations with neo-liberal economics are premised on individualism, entrepreneurship, limitless production and capital accumulation, with minimalist government regulation and the promotion of self-regulation; all fuelled by commodification and mass production, advertising and consumption.
(ii) Structuralism is manifested by left-wing politics such as socialism and communism based on collective needs and corresponding production, with central state control and regulation.
(iii) Interventionist, capitalism but with some government regulation in order to avoid excessive damage to society and environment.
(iv) Alternative—a broad spectrum rejecting extravagances and failures of the aforementioned systems, but emphasizing people-environment as core standpoints, promoted by many environmental-social movements such as Greenpeace (ESRC GPID 2021).

With changing technologies, in the archaeology of societal evolution, due to innovation and diffusion, the power of know-how and equipment had to be negotiated within balances of influence in society so as to prevent recurring damage and violence and thus develop institutions necessitating regulation (Y.N. Harari). There have been iterations of this depending on place, context and power dynamics, within and between societies, and core-periphery political economies, including imperial and post-colonial relationships. All technology and development paths are not necessarily beneficial to sustainability; there is not a one size fits all. Appropriate technology policies have to be mediated between governing powers and populace.

History is replete with examples of too much top-down governmental imposition typified in colonial projects and totalitarian systems like Fascism, Nazism and Soviet

Communism and their legacies, while extreme bottom-up action runs destructive dangers like anarchy, e.g. Albania (1997) and Somalia (1991–2006). Global audiences were astounded seeing the mob attack on the US Capitol on 6 January 2021; but the democratic institutions and rule of law prevailed. A year later, 24 February 2022, audiences worldwide were stunned by the Russian invasion of Ukraine. Hence, top-down and bottom-up, nationally and internationally, need to moderate via institutions to legislate for workable sustainable environments, society and political economy, or else face negative consequences ranging from global warming to extreme poverty, conflict, excessive transnational corporation power, e.g. Facebook, Amazon, Apple, Microsoft, Google, Wauwe and evolving technocracies.

Key variables in SDG-16 centre on place and power dynamics. Thus, concepts from geopolitics (i.e. geo—territory/earth, politics—power) provide crucial insights on human territoriality, i.e. protection of space, resources, culture and identity at whatever geographical scale, which is being seriously challenged by globalization, often driven by big business, criminal cartels and activities of predator state regimes. Historically, the greatest expression of this territoriality was statehood and imperial empire hubs but eventually in the form of the Westphalian nation-state model with its boundaries, upon which the global political architecture is built. By their nature, states transition internally and externally attempting to balance centripetal and centrifugal forces, and so their boundaries are not immutable (O'Reilly 2019).

In 2022, there were 193 UN member states, and 51 in 1945, 117 in 1965 and 188 in 1999, reflecting the increasing number of states due to the drive for 'national independence', ending of colonial empires and dynamic political-economy alignments. The EU (27 states) as a geo(economic)-(geo)political entity embodies concepts of an inter-state intergovernmental organization with traits of federalism. It promotes freedom of movement of: goods, capital, services, workers and citizens, regulated neoliberalism, but emphasizing fundamental values: respect for human rights, democracy, equality, rule of law and sustainable development (EU 2021). Notable is that in the history of the EEC/EU since its foundation (1957), there have been no armed conflicts between its member states. However, this cannot be taken for granted as witnessed by internal and external threats (EUROPA European Union 2021a, 2021b).

Despite collapse of neighbouring Yugoslavia and pursuant Balkan Wars (1990s) with refugee flows, subsequently the majority of new states democratically voted to join the EU, while the rest remain official applicant states, but with EU investment in their application of SDG-16.

Within the Union, there have been attempts to undermine the achievements of the EU Acquis Communitaire (EUROPA EUR-LEX 2021) by activities in Hungary under the Orbán government and that of Andrzej Duda in Poland appealing to populism within their electorates.

In the EU as elsewhere, there is the impact of the Dark Web promoting extremism, e.g. racial or cultural hatred, neo-Nazism, political-religious radicalization and terrorist Jihadi phenomena, linking up people inside-outside the Union, leading to atrocities in France, Britain, Spain, Germany and elsewhere.

Growth in populism is being sustained by groups and politicians, especially via social media. This was exemplified by extreme UK Brexiteer supporters and actions of the US Trump Administration from 2016 on. However, the most blatant attempted destabilization of the EU and democracy project were witnessed as of 24 February 2022, with the Russian invasion of Ukraine. Russia, having a permanent seat and veto powers in the UN Security Council, has abused the ideals of this global governance forum in attempting to justify its war against Ukraine.

BOX: The EU—Geographical Facts.

In 2021, the EU covered 4 million km^2 with 446 million inhabitants—the world's third largest population after China and India. By area, France is the biggest EU country and Malta the smallest. Germany has the largest population (83 million residents) with almost 19% of the total EU population (2020), followed by France with 15%, Italy 13.5%, Spain 10.6% and Poland 8.5%. France and Ireland have the highest birth rates while the most densely populated is Malta, and the least is Finland. Hence, the spatial unification of EU countries with their diversities and pooling of sovereignty via democratic methods and institutions is highly significant in world history (EUROPA, the EU in Brief, 2021. https://europa.eu/european-union/about-eu/eu-in-brief_en).

With this in mind, it could be posited that the agenda of the SDGs and especially No. 16 is too vast for it to be achieved. Nonetheless, citizens have no choice but to build on MDG achievements, to confront non-sustainable practices or else face increasing catastrophes within and between countries as witnessed during the Yugoslav Wars (1991–2001), Russian invasion of Ukraine (2022), Iraq and Syria (since 2003) leading to emergencies with huge refugee flows.

Here, education is pivotal in raising awareness, competencies and skills regarding the SDGs, and No. 16 enhancing the role of non-profit bottom-up organizations alongside development possibilities offered in the digital era.

The UN and SDG-16

Embedded in the SDG architecture is multifaceted research from all the sciences offering holistic perspectives on sustainability. However, the sciences by their essence constantly progress, and so the necessity to communicate this to government and public alike. Overall, policy thrust can only be as strong as its constituent parts including Geography, being cognizant of the nexus between geopolitics—power, conflict, peace-building, development and action—national and international.

SDG-16 has twelve targets to be achieved by 2030. Progress is measured by 23 indicators.

Goal 16 has ten outcome targets to:

(1) Reduce violence.
(2) Protect children from abuse, exploitation, trafficking and violence.
(3) Promote the rule of law and ensure equal access to justice.
(4) Combat organized crime and illicit financial and arms flows.
(5) Reduce corruption and bribery.
(6) Develop effective, accountable and transparent institutions.
(7) Ensure responsive, inclusive and representative decision-making.
(8) Strengthen participation in global governance.
(9) Provide universal legal identity.
(10) Ensure public access to information and protect fundamental freedoms.

Included are two means of achieving targets:

(i) To strengthen national institutions to prevent violence and combat crime and terrorism.
(ii) To promote and enforce non-discriminatory laws and policies.

The components of SDG-16: targets, measurement tools, time scale (2015–2030), organizational responsibilities and top-down and bottom-up mechanisms—are laid out in user-friendly ways on the United Nations (UN) Sustainable Development Goals (SDGs) webpages (Oslo Governance Centre. https://www.undp.org/policy-centre/oslo/sdg-16-measurement-and-monitoring. Accessed 30 November 2022).

Worldwide, the SDG-16 blueprint has been adapted by intergovernmental organizations including the EU, Council of Europe and national and regional governments, with educational authorities. The importance given to NGOs and civil society underlines the fact that the SDGs will not work without active citizenship as acknowledged by multiple organizations, e.g. IMF (International Monetary Fund), World Bank and WTO (World Trade Organization). However, realistically, collaboration in a sustainable development approach is dependent on structural cultures within societies, and citizens' possibility for action depending on democracy levels and political governance cultures. Fundamental is the nexus between citizens' human rights, endowments and entitlements regarding action. Existing institutions supporting SDG values need to be enhanced, and where they do not exist, have to be created. At each enlargement stage of the EU, such challenges had to be confronted, keeping in mind the Acquis Communitaire clause for applicant states, but especially institutional capacity building, furthering human and citizens' rights as is evident in the Balkan region including Serbia and North Macedonia, but also the future of Bosnia-Herzegovina and Kosovo (EC 2021).

BOX: Interlinkages between governance and security—SDG-16.

In 2021, appraising implementation of SDG-16, the IPI Global Observatory stated: Interlinkages between governance and security exist. Hence, the carrying out of SDG-16 remains vital for achieving sustainable peace and development. Yet global progress on implementing Goal 16 is uneven, stagnant and at its current pace unattainable by 2030. The global health pandemic (2020–2022) illustrated the existential significance of effective inclusive governance. The way forward for SDG-16 continues to depend on states' ability to navigate all-inclusive policy coherence and purposeful integration of local development actors. Despite collaboration, progress on SDG-16 has been steadily backsliding as illustrated by the Global State of Democracy Indices that found significant declines in 12 of the 18 aspects it used to measure progress on SDG-16, counting a reduction in all forms of violence (Target 16.1), estimated to intensify by 10–46% by 2030. Nonetheless, a significant sample of progress is that of the government of Denmark as an early leader in progressing integrated SDG-16 approaches between its branches of government while using multi-stakeholder inclusion monitoring targets across national frameworks, including its foreign policy. Other significant samples with steps towards national implementation mechanisms for policy coherence were also taken in Mongolia and Georgia. (IPI: https://theglobalobservatory.org/2021/06/revitalizing-progress-for-sdg-16-on-peace-justice-and-inclusion/).

Regarding possibilities for multifaceted development, the UNDP Human Development Index (HDI) remains a major data source for policy makers (UNDP 2021). It gives a summary measure of average achievement in key HD dimensions: (i) longevity and health, (ii) education and (iii) economic standard of living. Countries are categorized into HDI levels of Low, Medium, High and Very High. Of the 189 countries measured in 2020, in the top ten ranked in the Very High were 8 EU/EFTA states: Norway, Ireland, Switzerland, Iceland, Germany, Sweden, Netherlands and Denmark, while in the Low the last 10 were: Eritrea, Mozambique, Burkina Faso, Sierra Leone, Mali, Burundi, South Sudan, Chad, Central African Republic and Niger. Other significant rankings were: Hong Kong China—SAR (4), UK (13), USA (17), Russia (52), Ukraine (74), China (85), Syria (151), Yemen (179) and North Korea (data not available) (UNDP 2020).

Regarding SDG-16, many organizations monitoring human rights and institutions produce reports. For instance, Freedom House conducts research and advocacy on democracy, political freedom and human rights. Concerning the Democracy Index, the Economist Intelligence Unit—EIU Index is based on 60 indicators in five different categories, measuring pluralism, civil liberties and political culture (EIU 2021). Interactive GIS maps bring life to these data. In addition to a numeric score ranking, the index categorizes each country into one of four regime types as in 2022; here is a random sample:

- Full democracies
  (Rank: 1 Norway, 3 Finland, 18 UK);
- Flawed democracies
  (Rank: 26 USA, 51 Poland, 58 Hungary, 61 Romania);

- Hybrid systems
  (86 Mexico, 87 Ukraine, 96 Morocco);
- Authoritarian.
  (Rank: 124 Russia, 148 China, 167 Afghanistan).

BOX: EIU Global Democracy Index.

According to EIU (2021), under half (45.7%) of the world's population live in a democracy of some sort, a significant decline from 2020 (49.4%). Fewer (6.4%) reside in a 'full democracy'; this level is down from 8.4% in 2020, after two countries (Chile and Spain) were downgraded to 'flawed'. Over a third of the world's population (37.1%) live under authoritarian rule, a large percentage of which is in China (Democracy Index 2021) (https://www.eiu.com/n/democracy-index-2021-less-than-half-the-world-lives-in-a-democracy/).

The Global Democracy Ranking group measures the quality of democracy using a political dimension (civil liberties, gender political equality, press freedom, transparency and alternation of power) for 50% of the score—then tabulates five non-political dimensions for the other half of the total. With this in mind, the Human Freedom Index reminds us of the challenges in defining freedom. Transparency International's mission is to combat global corruption with civil societal anti-corruption measures and to prevent criminal activities arising from corruption. Its publications include the Global Corruption Barometer and Corruption Perceptions Index. GIS map layering of such data offers significant correlation patterns as does Forbes Annual 'Billionaire' Reports and accompanying maps (see home websites of the above organizations for further reading).

BOX: Reporters Without Borders (RSF).

The sterling work of such NGOs as Reporters Without Borders (RSF) often comes at a high human cost to journalists due to its aim of safeguarding the right to freedom of information and free speech, which is anathema to lies, corruption, injustice and crime whether in governance, business or criminal worlds of drugs, human trafficking, etc. From 1 January–31 March 2022, 21 journalists and 2 media assistants were killed; those imprisoned included 365 journalists, 95 citizen journalists and 23 media assistants (https://rsf.org/en/barometer).

RSF's work complements such NGOs as MSF (Doctors Without Borders) that aims to provide medical assistance to people affected by conflict, epidemics, disasters or exclusion from health care. MSF's actions are guided by medical ethics, impartiality, independence and neutrality. Kernel to this is a human rights approach, e.g.

rescue of migrants and asylum seekers in the Mediterranean Sea especially as of 2016 and in their trek through the Balkans. During the COVID-19 crisis (2020–21), MSF was active in Italy, Spain, Switzerland, France, Norway, Greece, Belgium, Ukraine, Russia, MENA, Asia, Africa and Latin America. MSF work includes Témoignage—or witnessing—speaking out about what is happening on the ground and provides data on behalf of ordinary people: to bring abuses and intolerable situations to the public, e.g. Yemen with CORONAVIRUS and war—both civil and proxy (MSF, https://www.msf.org/).

As with real time event-news, implicit is time–space geographies with the use of GIS. This was obvious in tracking the pandemic, at national and international scales feeding into research centres such as the John's Hopkins University CORONAVIRUS Resource Centre (https://CORONAVIRUS.jhu.edu/map.html), ECDC (EU) and WHO. Citizens and governments were reminded of their vulnerability and need to strengthen SDG-16 everywhere. This fragility was exemplified again on 26 March 2022, when the WHO stated that there had been over 70 recorded separate attacks on hospitals, ambulances and doctors in Ukraine since the Russian invasion on 24 February 2022.

SDG-16: Emergency, Crisis or Disaster

The impact of any humanitarian emergency or disaster is directly proportional to the levels of development and coping capacities of the individual community, region or country affected. Such emergencies cause 'interruptions' in development. There is no simple historical linear process to follow, due to the multifaceted aspects of 'development' that occur in the 'current' local, national and international enmeshed environments (O'Reilly 2019, pp. 119–185). With levels of poverty and vulnerability, citizens face hazards and risks from phenomena that geographers are familiar with.

Natural disasters include earthquakes as struck Greece, Turkey, Croatia, Russia, Iran, Indonesia, Mexico and Puerto Rico to name some in 2020. Examples in this natural category include flooding, drought and forest fires intensified by global warming. The Paris Agreement (2016)—UN Framework Convention on Climate Change (UNFCCC)—mitigation, adaptation and finance was negotiated by 196 state parties and adopted by consensus. By 2021, 191 members of the UNFCCC were parties to the Agreement. Of the six UNFCCC member states which had not ratified it, the only major emitters are Iran, Iraq and Turkey. In line with unilateralist standpoints of the Trump administration (2016–2021), the USA withdrew from the Agreement in 2020, but re-joined in 2021 under the Biden administration (UNCC 2021).

BOX: COVID-19—Countries with the highest percentage of deaths per 1000 population.

The COVID-19 pandemic starting in 2019 in Wuhan, China, and continuing with iterations still in 2022, has affected citizens globally regarding health and longevity, economics from the local, individual, family and community levels to national/international scales and consequently geopolitics with geo-economics. Based on statistics available for the highest percentage of deaths per 1000 population, due to COVID-19 and keeping in mind diverse local and national institutional systems for reporting deaths, the countries with the highest rankings (1–20) are: Mexico, Indonesia, Brazil, Russia, Poland, Chile, Philippines, USA, India, Italy, Greece, Spain, China, UK, Thailand, Germany, France Japan, Australia and South Korea (https://CORONAVIRUS.jhu.edu/data/mortality) (Accessed 6 April 2022).

Levels of contingency planning for such ‘natural’ occurrences at national and international scales have been tested by COVID-19, but especially the basic facilities available for citizens during lockdowns. Cognizance is needed for workers being dependent, or paid by the hour or daily, in contrast to assured wages and government compensatory schemes for people forced out of employment due to illness and lockdowns, e.g. India and Brazil. In post-pandemic environments, doubtlessly many official inquiries will yield significant ‘what have we learned’ data in countries with the financial means, reliable data, institutional capacities and democratic will to do so. In states without the aforementioned advantages, and regarding the EIU Democracy Index—flawed democracies, hybrid systems and authoritarian regimes, the task for researching the multifaceted CORONAVIRUS narratives will be more onerous, e.g. geo-locational, ethnic, cultural, socio-economic, occupation-type, front-line staff ethnic or racial composition, etc. Traumatic precedents suggest that experiences and memories will remain strong in the populations affected and will be passed to future generations’ sense of grievance concerning relationships with state institutions (O’Reilly 2020). Essentially, while the CORONAVIRUS started as a ‘natural hazard’, it became a human-made catastrophe in many contexts, e.g. Brazil, India, Mexico and elsewhere due to ‘policy decisions’ taken at various times and weak institutions. In the mature democracies such as the USA and UK, as the COVID-19 crisis unfolded, some observers referenced the nineteenth century root values of laissez-faire capitalism alongside Darwinism aspects in its evolution and contested colonial government responses, prioritizing ‘market forces’ in famine-epidemic environments in India and Ireland.

Debates on financing and supply of vaccine are reminiscent of the HIV/AIDS epidemic/pandemic in the 1980s–1990s and accessing antiretroviral AZT medication. In 2020, the WHO expressed concerns that some unilateral deals with wealthy countries would make the COVID-19 vaccines inaccessible to many people in the Global South and to prevent vaccine nationalism, for ethical and practical reasons as COVID-19 knows no national boundaries. Citizens are also coping with concepts regarding disease denialism, refusing the existence of COVID-19, or the benefits of inoculation, or ethnicization or racialization regarding disease sources, origins and transmissibility, alongside pseudo-science, hate speech and so forth feeding into ignorance and populism.

Human-made catastrophes are usually due to human rights abuses, civil and international wars, crimes against humanity, regimes that do not protect, or abuse their own citizens, etc. Such an approach, is the antithesis of SDG-16. The EU and mature liberal democracies pride themselves as role models in the creation of institutions that enhance human rights and SDG-16. Nonetheless, in May 2020 in the USA, the killing of George Floyd by police led to outcries nationally and internationally with demands for a 're-examination' of systemic discrimination in (state) institutional cultures whether in the rich or developing countries. Interestingly, in light of the above, in May/June 2021, Joe Biden was the first US President to recognize and attend centennial commemorations for the Tulsa Massacre (1921), when mobs of Whites, many of them deputized and given weapons by city officials, attacked Black residents and burned homes and businesses of the Greenwood District in Tulsa, Oklahoma. This event had been airbrushed from official memory, including school curricula. This is only an example, not suggesting that the USA has a monopoly on human rights abuses, and one has only to check out the webpages of Amnesty International or Freedom House. The point is that despite weaknesses in the US system, there exists the will and means to adapt and enhance institutions and cultures that promote human rights at home and abroad (UN 2021).

Technological emergencies range from nuclear to chemical spillage. Extreme examples include nuclear accidents in Chernobyl, Ukraine (1986), then part of the USSR, and in Fukushima, Japan (2011). In Chernobyl, the local, Ukrainian and international fears were reignited in February–March 2022, when Russian forces seized the nuclear plant. Such catastrophes can overshadow technological, chemical and other pollutant crises taking place. For instance, on 4 August 2020, over 2750 tons of ammonium nitrate stored at the port city of Beirut in Lebanon exploded, causing 207 deaths, 7500 injuries, US$15 billion in property damage and leaving 300,000 people homeless. Nitrate had been stored in a warehouse without proper safety measures for over six years. Port employees stated that they had informed government authorities of the risks. Many Lebanese citizens see this as yet another failure of the state to deliver any credible form of governance, and so the socio-economic dependence of many citizens on groups like Hezbollah, that was designated a terrorist organization by the EU, USA and all Arab League countries except two (Wikipedia Beirut Explosion 2020).

On 20 May 2021, fire erupted on a vessel carrying 1486 containers, including 25 tons of nitric acid and other chemicals when the ship was anchored 9.5 nautical miles off Sri Lanka; by June, there were oil and chemical spillages from the sinking vessel. Coastal communities bear the environmental consequences, and economic hits to fishermen and tourism (Aljazeera 2021).

Everyday, silent killer pollutants are usually less evident to citizens and act over longer periods before manifesting themselves in a crisis way. This is typified by air and water quality measurements depending on where one lives. For Europe, statistics are available from various governmental sources and NGOs such as Greenpeace and EU EUROPA websites.

Complex disasters include various combinations of the above three categories. While extreme examples have been used above, the key point is that non-sustainable ecological, economic and socio-cultural collapses find their genesis in small geographical scales and processes where positive regulation is not enforced, or lacking, or does not have institutional structures to mitigate and stop anti-sustainable activities, including those produced by 'big business'. Bearing witness to this are such narratives as those of Syria, Somalia, Myanmar, Chad, Iraq, Yemen, DRC, CAR, Liberia, Lebanon, Afghanistan, Sudan and South Sudan alongside state predation, i.e. corrupt or crony corralling of resources at the expense of other groups (FFP Fragile States Index 2021).

The first photographic image of Planet Earth was taken in 1972 by scientists of NASA's Moon mission. Worldwide, people witnessed the physical integrity of Planet Earth without human constructs of boundaries and flags. Simultaneously, citizens and scientists were grappling with the population explosion, Green Revolution, food production and ecological carrying capacities, amidst discourses of the so-called First, Second and Third World countries and Cold War ideological rhetoric. The geopolitical and geo-economic dynamics of the old colonial order (eighteenth century—1950s) were changing, heralding in intensified globalization spearheaded by Fordism. With implosion of the USSR (1991), Frances Fukuyama argued that there was now the ascendancy of Western liberal democracy. He contended that humanity had reached not just the passing of a particular period of post-war history, but the end of history itself (Fukuyama 1989). Essentially, Fukuyama was saying that we had reached the end point of mankind's ideological evolution and universalization of Western liberal democracy as the final form of human government. The authorities in China disagreed, but adapted aspects of free-market capitalism to its Maoist-Marxist-Leninist model that was updated, but remained under control of Communist Party institutions, while berating Western social constructs of individualism and human rights as specificities of Western cultural ideological power games.

With the implosion of the Soviet system and geopolitical dynamics, the EEC/EU accelerated its integration processes incorporating new member states from Central, Eastern, Balkan and Southern Europe (1994–2004), rising from 12 member states in 1991 to 27 in 2021. A core principle in adhesion to the EU remained that applicants accepted the Acquis Communitaire, norms and legislation regarding peace, justice and strong institutions. Within EU states, and between them and third parties, the realpolitik had to be juxtaposed with ideals of democracy modulating the inherent dynamics of liberal capitalism globalization. Old left- and right-wing binary discourses were no longer fit for purpose. Europe has been seeking to create a Third Way attempting to reconcile social and political-economic dynamics by advocating syntheses of centre-right economic platforms with centre-left social policies. Hence, there exists a socio-political malaise, reflected in the gap between what people expect and governments deliver, all reflected in rising populism in France, Germany, Netherlands, Greece, Turkey and Vise-grád countries. Populism endangers the hard won fruits of democracy and international cooperation. In response to Fukuyama, politicians and citizens are trying to deal with the shock of neoliberal globalisation, and find a new ideological blueprint, in the search for a new world order. This is manifesting itself in the culture wars being experienced in the USA and elsewhere, and in the politics of nostalgia suggesting that certainty and stability can be achieved by recreating idealized past historical eras in the present such as empire, ethnic or racial supremacy, and so forth e.g. Russian attack on Ukraine in 2022.

Factors fuelling populism in Europe include: globalization; declining birth rates; ageing population alongside the economic dynamics for immigration; young(er) populist politicians targeting 'fear' in the grey vote; Eurozone's austerity-stagnation experiences especially since the 2007 Crash; and a 'one size fits all' response, frustrating populations in individual member countries. However, the challenge is the Distance of Brussels in ordinary citizens' perceptions, and consequently a need for reinforcing shared European values by everyday citizens (Open University 2020; Bergh and Kärnä 2020).

This became especially evident in 2016–2020 to citizens hearing slogans like 'Make US great again' (who exactly, and at whose expense) in the USA, Russia and elsewhere. Empire-nostalgia was reflected in Brexiteers' rhetoric in the UK, constructed on English/British nationalism—with fictional travel to past empires in a Utopian future. In the 2016 referendum, for the UK as a whole the 'Leave' vote gained a majority of 1,269,501 (3.78%) over the 'Remain' vote. However, electoral majorities in Scotland and Northern Ireland voted to Remain in the EU (BBC 2016) with the destabilizing long-term consequences of that still unfolding. Nationalistic populist divisions also emerged within Hungary and Poland, and of course the emblematic 'strongman', not forgetting the strong-woman rhetoric of Marine Le Pen in France.

Duplicity of 'strongman' populist approaches reached spectacular heights in the US elections in 2020 with the sitting President Trump refusing to accept electoral defeat and peaceful transition of power to the President Elect Joe Biden. This culminated in a Trump-supporting riot mob storming the US Capitol in Washington DC (6 January 2021) with images being transmitted worldwide from the historic seat of modern democracy. This populist phenomenon has not been unique to so-called Full and Flawed Democracies but to other countries including India, Brazil and Philippines. The malaise was exasperated by COVID-19 (2020–2021) and varying responses to it, within and outside the EU.

Nonetheless, despite Fukuyama's end of history thesis, while witnessing social-political phenomena undermining the 'taken for granted' democracy in the EU, Europe and USA, the Putin regime in Russia and oligarchs in their echo-chamber developed a campaign for annexation of Crimea (2014) and invasion of Ukraine (2022)—based on old style extreme nationalism, territory and resource grab, and empire nostalgia, framed in historical rhetoric, a harbinger of future assaults on democracies in the region. Significantly, attacks galvanized Ukraine, the EU and international institutions, both politically and financially into a raft of actions in defence of Ukraine and democratic institutions. Ukraine is emblematic of a liberal democracy geographically adjacent to EU borders and is an EU applicant country.

According to Reuters (2 March 2022), due to the UN Security Council impasse (i.e. Russian veto power), the UN General Assembly overwhelmingly voted to reprimand Russia for invading Ukraine and demanded that Moscow stop fighting and withdraw its forces, an action that aims to isolate Russia at the world body. The resolution, supported by 141 of the UN General Assembly's 193 members, passed in a rare emergency session. Russia was joined by Belarus (a puppet regime state of Russia), which has served as a launch pad for Russian forces. Eritrea, North Korea and Syria voted against the UNGA resolution. Thirty-five members, significantly including China, abstained. In other words, they did not overtly try to block it. Taking into consideration crucial ethical arguments made by many UN states, and realpolitik stances of so many, only 5 states supported Russia. In short, the vast majority wants the rule of law and so avoid an international war. This UN stance regarding Ukraine is mirrored in EU institutions and actions, and profoundly by the activities of ordinary citizens and NGOs. The history of this horrible water-shed time has yet to be written in the future.

Hence, the need to enhance stability and democratic ideals on the ground via SDG-16 are evident. In the body politic, issues of economic justice, identity and citizenship have to be catered for alongside the weight of systemic negative social-political legacies. There has to be socio-political balances within states and between them. Implicit here are the SDGs, with Goals 16, 4 and 5, quality education and gender equality.

Integrating SDG-16 into Education

Practical awareness of SDGs has to be transmitted horizontally and transversely in pedagogy. For example, EDIW (Education for an Interdependent World) is a non-profit working with universities, international organizations and professional bodies aiming to empower young people in Higher Education fostering actions and projects to build inclusive societies. It progresses networks and empowerment structures for young professionals and students (EDIW 2021). EUROGEO is highly active in supporting such non-profits as is exemplified by its roles in the INGOs at the Council of Europe.

Case study 1. With EUROGEO support, a core textbook: Aligning Geopolitics, Humanitarian Action and Geography in Times of Conflict, exploring the nexus with institutions and governance was produced (O'Reilly 2019). A sample of one of the activities for continuous assessment (CA) aiming to make statistics meaningful and humanize them for students in the learning process is as follows: de-constructing the multi-layered interconnections in the UN Human Development Index (HDI). Students combine group and individual work activity: Taking a country of their choice from the UNDP Low HDI category, they analyse it for levels of development and emergencies, emphasizing the physical, human and geopolitical variables. The steps for doing this are laid out regarding the research, production and delivery of a report and PPT summary (O'Reilly 2019, pp. 239–243).

Case study 2. The above research and core text were seminal in developing a module: Geographical Research Methods (GRM): Territory and Power. This was enhanced by access to EUROGEO projects including GeoDem, GeoCapabilities, DB: Developing Digital Literacy, Digital Earth and so forth (EUROGEO Projects 2021). It focuses on methods and tools for creating, analysing and presenting data. Primary and secondary sources are used with quantitative and qualitative methods. Emphasis is on sources and presentation skills, tools and applications. Major thematic areas include local, national and international development. These research exercise activities worked especially well in Zoom breakout room sessions during the pandemic emergency (2020–2021) enhancing innovative T&L and PBL.

Students are required to: locate features on maps in real space–time; devise and undertake project CA research emphasizing empowerment, citizenship and sustainable development underlining SDG-16. This aims to explore territorial scales and power dynamics, within and between Ireland and other states through a series of projects. This includes research and fieldwork, lectures, seminars, guest speakers and workshops. Progressively students acquire competencies and skills—digital, search and presentation, methodologies, report writing, communications—visual, written and oral, e.g. PPT, mp4 and so forth. This is underpinned with Module Aids and workbook, directed reading and videos. Interconnected Individual Projects are—1: Development challenges in my local home area; 2: Ireland/EU and international development; 3: The power of NGOs in the digital age; and 4: Comparative perspectives from Ireland and another country, based on international link-up sessions via Zoom (e.g. Israel in 2021 and 2022).

Conceptually, CA projects 1–4 are created to go from the individuals' daily realities within his/her own environment and problems encountered, so as to search out the processes of 'how to fix' issues from the 'grassroots' upwards, e.g. transport, water quality, anti-social behaviour, drug abuse and so forth; topics are suggested by students. Having listed two issues in his/her local area, individuals then gravitate towards other students with broadly similar themes. This facilitates interaction with access to digital devices. Students empathize with issues in the other student's local area, and not just the big national and international themes whereby 'local realities' can become lost. Students become more aware of intricate political processes for 'fixing the problem', firstly having researched in their own communities and then needing to interface with local and national institutions seeking solutions.

Project 2 explores problems in the Global South. The aim is to empower students to 'discover' links between his/her experiences in Project 1 and to empathize with citizens in other societies 'to find solutions' to local problems. Students explore policies and actions of the Irish State and Aid, its interconnections with the EU, UN and intergovernmental institutions, especially projects with bilateral Irish Aid countries, e.g. Ethiopia, Uganda and East Timor. Development NGOs are examined and relationships between the Irish state and public, and projects in partner countries. Linkages between official and non-official state aid and citizen lobbying processes are explored through workshops provided by top-down and bottom-up agencies, e.g. Irish Aid—Department of Foreign Affairs, CONCERN, MSF (Doctors without Borders).

The role of NGOs imbedded in Projects 1–2 feeds into Project 3. Students research the non-profit UPLIFT NGO in enhancing democracy. UPLIFT mounts lobbying campaigns, e.g. targeted specific Fair Trade issues and businesses, anti-plastic and environmental campaigns, etc. UPLIFT's website illustrates that campaigns cover all dimensions of the SDGs and centrality of SDG-16. Members of the public can start a campaign of their own or join someone else's. Several students while carrying out research have joined UPLIFT to test and highlight issues in their projects. Institutions, politicians and business sectors ignore UPLIFT campaigns at their peril, in the ballot box or in their sales revenue (UPLIFT 2021).

The results of this are contrasted in comparative work with other NGOs that students have encountered in Projects 1 and 2. Here, greater cognizance of the actual situation at home and abroad is enhanced.

In Project 4, there is linkup with Geography students in another country. Iterations of this have taken place over the years with universities in the Netherlands, Switzerland and USA, and in 2021, 2022 with Israel (O'Reilly 2017). The aim is for students and teachers to communicate while working on common tasks despite differences in culture, language and environments. This entails mixed group projects feeding into larger themed class work. Communications were facilitated by Zoom and WhatsApp groups. Whole class sessions for the combined group of 46 students were kept to a minimum. Among their main tasks is to: introduce and share their 'own' and 'national' geographies with the 'other'; (ii) develop joint student fieldtrip itineraries, competencies and skills for imagined trips. Implicit in Project 4 is comparing/contrasting development issues in Ireland and Israel, institutional organization, peace-building and development as promoted in SDG-16.

Conclusions

In order for SDG-16 to be workable for citizens, Peace, Justice and Strong Institutions promoting inclusive societies must be interpreted at multiple scales—local to global and in varying contexts from geographical perspectives, i.e. the human-environment nexus. Geographical theory and concepts are derived from researching territorial and power dynamics (i.e. geopolitics) within and between countries juxtaposed with variables in SDG-16. Hence, top-down and bottom-up collaboration is imperative.

The UN organization epitomizes attempts at global governance, while the EU promotes the centrality of strong institution building and democratic values at home and abroad. In 2022, there were 193 UN member states, but only 51 in 1945. However, five powerful countries (i.e. the Big 5) continue to hold a right of veto, having permanent seats on the UN Security Council. Since 2020, many peoples 'taken for granted' worlds were endangered with the CORONAVIRUS pandemic, and then witnessing the Russian invasion of Ukraine. Globally, citizens looked for leadership from UN and EU institutions despite their numerous limitations. In response to war and crimes against humanity, major examples of international institutional cooperation include the International Criminal Court (ICC 2021) and the UN Responsibility to Protect

(R2P) (UN R2P 2021). But for these to have best results for humanity, there must be genuine 'buy in' from the Big Five on the UNSC—USA, Russia, China, France and UK. Realistically, by stealth the UNGA countries must bring about restructuring of the UNSC. The five permanent members, like the proverbial turkey, will not vote for Christmas. However, positive results can only be achieved with collaboration, justice, rule of law and strong institutions at local and national scales, driven by the willingness of NGOs and communities—making international law and institutions more 'people-centred' than 'state-centric'. The UN R2P has three core pillars:

(I) Each individual state has the responsibility to protect its population from genocide, war crimes, ethnic cleansing and crimes against humanity.
(II) International assistance and capacity building—states pledge to assist each other in their protection responsibilities.
(III) If any state is manifestly failing (or refusing) in its protection responsibilities, then states (but as approved by the UN Security Council) should take collective action to protect the population. This covers a range of activities from diplomatic protests, to sanctions to military action alongside delivery of humanitarian aid, and institution building in the post-conflict period (UN R2P (2021) UN Office on Genocide Prevention and the Responsibility to Protect; O'Reilly 2019, pp. 199–226).

The geographical sciences underpin the SDGs, being based on investigating human-environmental nexus within specific areas and globally searching for cartographic patterns and explanations supported by categorization. This was revolutionized by GIS layering techniques and Earth System Science (ESS), e.g. monitoring interactions between the anthroposphere and other geospheres. The role of Geography and education in furthering the SDGs is core for this and future generations. Reinforcing this are samples of geographical education projects that were briefly discussed above.

Decoding the sterling work of many experts regarding the creation, aims and progress measurements of the SDGs is not evident for ordinary citizens and indeed many policy makers. Interlinkages between governance and security exist; thus, SDG-16 remains vital. But by 2022, progress in implementing Goal 16 is uneven, stagnant and at its present pace probably unattainable by 2030. The CORONAVIRUS pandemic (2020–2022) showed the existential importance of effective and inclusive governance and its many weaknesses at contrasting national and international scales. Similarly, the Russian invasion of Ukraine seriously challenged the EU and UN. The way forward for SDG-16 depends on states' ability to manage all-inclusive policy coherence and focused integration of local development actors. According to the IPI Global Observatory, progress on SDG-16 has been slipping backwards in many areas (IPI 2021), as also illustrated by data from such non-profits as Amnesty International and the Global State of Democracy Indices that found significant declines in 12 of the 18 aspects it used to measure progress on SDG-16, e.g. reduction in all forms of violence (Target 16.1), estimated to increase by 10–46% by 2030. However, leader samples of progress include the government of Denmark in systematic integrated SDG-16 approaches between its branches of government, including multi-stakeholders monitoring targets across national frameworks, and its foreign policy strategy. Steps towards national implementation mechanisms for policy coherence have been significant in several other countries as diverse as Mongolia and Georgia. For SDG-16 to be achieved, increasing NGO and community 'buy in' collaboration are key aspects. Hence, governance institutions and organizations at local, national and international levels need the trust of their citizens. Abuse of power whether in Russia, Iran, Nigeria, UK, EU, Brazil or elsewhere undermines the SDG-16 aims.

In making sense of SDG-16, policy makers, educators and students have to be literate in decoding the UNDP HDI, indices, rankings and maps concerning human rights, Global Democracy, Transparency International and so forth. Data from multiple sources like these can be interlinked and updated thanks to GIS. SDG-16 remains core to EU policies at home and abroad.

Education ranging from UNESCO to national systems plays critical roles progressing the SDGs and in particular No. 16 that has to be normalized into everyday approaches to achieving sustainability. In order to counteract the dulling dangers of 'learning off lists', or 'box ticking' losing qualitative meaning, both transversal and horizontal approaches in pedagogy are imperative. In this context, EUROGEO has been playing significant roles at multiple levels.

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SDG 17. Strengthen the Means of Implementation and Revitalize the Global Partnership for Sustainable Development

Revitalizing the Global Alliances for Sustainable Development; Analyzing the Viability of SDG 17 Using Marine Conservation Case Studies in Europe

Elena Bulmer, Magali Riera Roca, and José Antonio de la Rosa

Abstract In 2019, the 2030 Agenda Accelerator was developed by the UN Department of Economic and Social Affairs (UN DESA) and the Partnering Initiative in collaboration with several other partners to "significantly help accelerate effective partnerships in support of the Sustainable Development Goals". Therefore, a systemic perspective is necessary when developing laws to implement sustainability policies effectively. This chapter will explore the importance and viability of SDG 17, "Partnering for the Goals" through the analysis of two marine conservation case studies based in Europe. More specifically, the applicability of SDG 17 will be analyzed to assess the viability of SDG 14, "Life Under Water". The SDGs were developed at the country level. However, specifically, SDG14 is a global endeavor. Unlike hazards affecting terrestrial habitats, marine threats are not geographically bound, like all marine environments connect to each other, and thereby all marine fauna and flora are affected equally by them on a global basis. A recent example of this is the problem with marine plastic debris. A plastic bottle may be thrown into the Mediterranean Sea and in Latin America. Malpractice in waste management in a specific geographic area may affect marine turtles everywhere as marine turtles are similarly not geographically bound and are affected everywhere by this now global problem.

Keyword Global alliances · Sustainable development goal 17 · Multi-stakeholder partnerships · Sustainable development · Project stakeholder management

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5_17

The Sustainable Development Goals of the United Nations and SDG 17

The 17 Sustainable Development Goals were developed at the United Nations (UN) Development Summit at Rio de Janeiro (RIO + 20) held in 2012. The main objective of this summit was to develop global goals that would provide a solution to global environmental, social, and economic problems. According to the United Nations, Sustainable Development aims (to satisfy) the needs of the present generation without compromising the ability of future generations to satisfy their own needs. This definition of the term "Sustainable Development" is included in the Bruntland report from 1987 that was developed by the World Commission on Environment and Development (WCED) to conceive long-term solutions related to sustainable development. The main topics covered included the international economy, population and human resources, food security, species ecosystems, energy, industry, and proposed legal principles for environmental protection. The new SDGs came into effect in 2015. There were 17 goals and 169 targets, and they were part of the adoption of a document entitled Transforming our World: The 2030 Agenda for Sustainable Development.

The seventeen SDGs encompass a set of global priorities that need to be addressed via a multi-actor type of governance. Governance, in this respect, is defined as "the sum of the many ways individuals and institutions, public and private, manage their common affairs" (Commission on Global Governance 1995). Generally, traditional governance was linked to only one set of actors. The context is however changing through the greater participation of a wider range of stakeholders, and therefore, no one sphere of governance is the preserve of solely one actor (Newell and Pattberg 2012; Newell 2000; Betsill and Correll 2008). "Traditional modes of state-based regulation have come to be seen as limited in their reach, effectiveness, authority or legitimacy in tackling complex global environmental problems" (Newell and Pattberg 2012: 366), such as those included in the SDGs. This change from government to governance has been demonstrated by a shift in the power distribution with a greater protagonist role for non-state actors such as non-governmental organizations and the civil society. Examples of multi-actor arrangements range from non-state actor initiatives to certification projects in such areas as mining and sustainable tourism.

The seventeenth SDG (SDG 17), "Partnerships for the Goals" the aim of which is to "strengthen the means of the implementation and revitalize the global partnership for sustainable development" is an example of a multi-actor type of governance (United Nations 2021a, b). In this regard implementation of the different targets of SDG 17, along with the development of alliances between the various stakeholders will help the execution of the rest of the SDGs. Moreover, SDG 17 states that "multi-stakeholder partnerships are important vehicles for promoting the sharing of knowledge, expertise, technologies, and financial resources to help the implementation of the SDGs in all countries, in particular the developing countries" (United Nations 2021a, b). The 2030 Agenda Accelerator was established in 2019 by the UN Department of Economic and Social Affairs (UN DESA) as well as the Partnering Initiative in association with several other partners to help facilitate the creation of successful partnerships in support of the Sustainable Development Goals (United Nations 2020). Thus, a holistic angle is necessary when developing laws to implement sustainability policies effectively. However, not only the governing authorities are essential to enforce change, but the necessary global efforts extend to all parties, thereby the need for SDG 17. Already, there are laws and regulations that would previously have been associated with solely one set of actors, but now are increasingly written collaboratively and legitimized through the involvement of different actors in their formulation and implementation.

This chapter will analyze Sustainable Development Goal 17 using two marine conservation projects located in two different European countries: (1) a marine turtle bycatch project in Valencia, Spain, and (2) a dolphin conservation project located in Normandy, France. Marine conservation projects are special contexts as they present environmental problems that transcend national boundaries. As national governments have been unable to agree a workable solution to these large-scale environmental challenges, non-state actors are providing alternative experimental approaches and innovative solutions (Newell and Pattberg 2012). A multi-actor governance perspective entailing novel partnerships and networks is therefore necessary, encompassing many different stakeholders. The two projects analyzed in this chapter are associated with Sustainable Development Goal 14, "Conserve and sustainably use the oceans, seas and marine resources".

Marine Conservation Project 1—Marine Turtle Bycatch Project in Valencia, Spain

The Valencian marine turtle project is an excellent case study to examine the challenges of working in a multi-actor governance context to achieve the project's mission: reducing marine turtle bycatch rates. In this sense, the specific project's objective may be linked to Target 14.2 of SDG 14, which is linked to the sustainable management and protection of marine and coastal ecosystems.

The analyzed marine turtle case study aimed at reducing bycatch rates by Spanish fishing fleets through a pilot study on the use of Turtle Excluding Devices (TEDs) in Calpe in the Levante Coast. The project's target species is the loggerhead turtle as it is the most prevalent species of turtle in the geographical region of the Mediterranean. It is led by the NGO Chelonia in collaboration with various stakeholders. This project is of special interest as it involves the use of innovation and technology to decrease sea turtle bycatch levels with TEDs by the area's fishermen. It aimed to reduce bycatch rates through the installation of TEDs in local fishing boats. If the project proved successful, the intention was to install TEDs in all the boats of the Valencian fishing fleet.

Marine turtles are endangered worldwide. The International Union for the Conservation of Nature (IUCN) classifies all seven marine turtle species as threatened. The IUCN is one of the largest conservation organizations worldwide and strives to provide “public, private, and non-governmental organizations with the knowledge and tools that enable human progress, economic development and nature conservation to occur together” (IUCN 2021).

Marine turtles are presently threatened by five main anthropogenic hazards: (i) impact of fishing, (ii) direct take, (iii) coastal development, (iv) pollution and pathogens, and (v) global warming. These threats affect all marine fauna and flora and not just marine mammals. Marine hazards are very different from those affecting terrestrial habitats, as they are not geographically bound. All marine environments are connected to each other, and thereby all threats affecting the marine environment will impact all marine fauna and flora. The marine plastic debris problem is just one example of this but one that is presently affecting our oceans worldwide. A plastic bottle may be thrown into the Mediterranean Sea and end up on a beach in Latin America. Malpractice in waste management in a specific geographical location may affect marine turtles globally as they are animals that are not geographically bound and are thus affected everywhere by this now global problem.

The project holding organization is the international NGO “Asociación Chelonia”, a conservation NGO established in 1997 and that possesses over twenty years of experience in marine conservation in the Iberian Peninsula and elsewhere. Its mission is based on research into and the sustainable management of natural resources. The scope of work of the organization was initially limited to the Iberian Peninsula but has expanded internationally since 2006 launching projects internationally, specifically in Latin America, Africa, Asia, and in several European countries. The organization carries out scientific conservation projects, as well as social projects, that aim to improve the socioeconomic level of the populations living near the areas that are being protected. Moreover, Chelonia has worked on marine turtle bycatch issues for many years and therefore has considerable expertise in this area.

In this respect, over the years, Chelonia has come to work with a realm of different stakeholders (listed below), with whom over time, the organization has come to establish a trustworthy relationship. Throughout this specific project’s execution, most project stakeholders (Fig. 1) participated cooperatively, as they all shared the same project vision which is to reduce marine turtle bycatch levels in fishing waters off the Levante Coast. However, there was one stakeholder that was difficult to deal with, namely the fishermen themselves. Nonetheless, with the help of the Valencian Government, the fishermen came to eventually support the project. The main project stakeholders are listed below (Bulmer and Del Prado-Higuera 2021a):

- *Project Holding organization: “Asociación Chelonia”* is a Spanish conservation NGO based in Madrid that possesses over twenty years of experience in marine conservation in the Iberian Peninsula.
- *Other NGOs based in Valencia a Galicia.*
- *Funders*: The project funders include the American Fish and Wildlife Service (FWS), and the Spanish “Fundación Biodiversidad”
- *State government*: The General Secretariat of Fishing of the Environment Ministry.

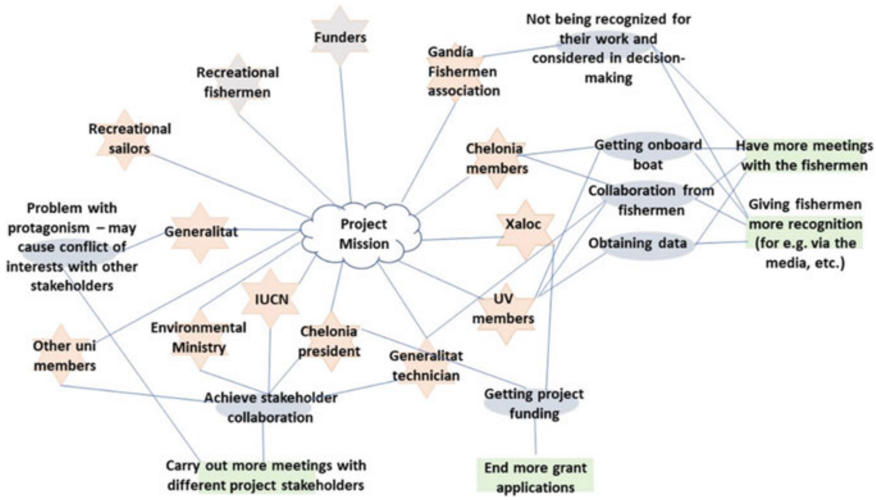

Fig. 1 Stakeholder map of the Valencia marine turtle conservation project (Bulmer and Del Prado-Higuera 2021a)

- *Regional Government of Valencia (Generalitat)*: Represented by the technician from the Environmental Department
- *Fishermen*: Only a representative from one fishermen association, that of Gandia, was interviewed.
- *Civil society*

All the members of the project holding organization Chelonia were found to support the project, and their perspective was very much aligned with that of the members of the other NGOs supporting the project such as Xaloc, and that of the scientific researchers from the University of Valencia (Bulmer and Del Prado-Higuera 2021a). As shown in Fig. 1, these stakeholders had three problems in common regarding the project objective; (i) the problem of getting onto the fishing vessels themselves, (ii) gaining the collaboration of the fishermen, and (iii) obtaining the necessary scientific data to be able to continue with their research. One of the UV scientists noted in February 2019, "I think that the most important would be the fishing part. Everything related to fishing, really everything, depends on the fishermen, on whether they want or not to collaborate". Without the fishermen, the scientists would not be able to get their data, nor complement the latter with qualitative data regarding the fishermen's experience at sea.

For the scientists (i.e., universities and the NGOs), the fishermen were undoubtedly the most difficult actors to deal with, especially at the beginning of the project. The fishing industry in Spain is a sector that is rather "closed" and difficult to deal with. It must be noted that the fishermen were probably the most sensitive stakeholders. The fishermen felt that the scientists were distanced from the working reality that they experienced. Fishing for them was their living, their way of living. It was no surprise therefore that they felt threatened by the scientists who just wanted to get onboard their boats to get their data. Therefore, the fishermen were reticent regarding enforcing changes in their way of working (i.e., that is through the installation of the TED devices on their boats). Part of the lack of trust on the part of the fishermen was often because they are often blamed for much of what happens at sea, such as marine conservation problems and the bycatching of specific marine fauna. “There are a multitude of factors that have an impact on fishing. Not the fishermen themselves but factors inherent in fishing itself as an activity… An example, No, I say again that we have already reduced our fishing activity by 38% so if the reduction in fish stocks had been because of us, then the sea would be full of fish by now” (President of the Gandia Fishing Association, 2019).

Over time, fishermen felt that their perspective was never really considered. When the different national and European authorities drew up conservation regulations for protecting marine turtles at a national or European level, they would base their reasoning and decision making on rigid scientific evidence. One of the trusted information sources is the IUCN that derives its knowledge from a compendium of scientific sources of experts that specialize in the observation and conservation of marine turtles (Bulmer and Del Prado-Higuera 2021a, b). However, could the fishermen get more protagonism in this respect? In this whole story, the fishermen did not want to suffer in any way from the bycatch issue. Firstly, the fishermen did not want to get into any legal complications because of this issue, and secondly, they did not want to project a negative image of themselves among the civil society. Therefore, one of their main priorities was to clear up their image. “It goes beyond saving the lives of many turtles, cleaning up the image of the fishermen is important” (President of Gandía fishermen’s association—Bulmer and Del Prado-Higuera 2021a).

During the execution of the project and with the aid of the Valencian Government, the fishermen came to support the bycatch project. The environmental representative from the Generalitat played a primordial role in advocating positive collaboration between the scientists and the fishermen. Through the charisma and empathy of the Generalitat environmental representative, he was able to obtain the collaboration of all project stakeholders. In the marine turtle project, he facilitated access for Chelonia and the scientists to the fishermen and their associations. Over time he was able to show the fishermen that the project holding organization was trustworthy. Presently, the Levante fishermen consider him to be “a fellow fisherman”, and it is not strange to maybe see him in a bar in Gandía having a beer with them. His active participation and collaboration with the fishermen over the past 26 years has helped to bring together over time the different project parties to ensure an active multidisciplinary collaboration between different stakeholders such as universities, NGOs, and local governments.

From their side, it was essential for the scientists to learn to be more empathetic and respectful when dealing with the fishermen. The scientists needed to understand that if the fishermen decided to participate in the project, that decision would have an impact on the quantities of fish caught by them and potentially affect their livelihoods. Furthermore, it should also be noted that fishing is a socioeconomic activity that needs to be viable over time, since much of society depends on seafood as part of their diet and thousands of fishermen and other parties depend on fish for their livelihoods.

In this multi-actor governance context, it is also interesting to highlight the role of the international and national jurisdictions. In Spain, the context is different to that of other European countries. At the national level, the conservation measures need to be promulgated by the environmental ministry (i.e., presently called the Ministerio para la Transición Ecológica). Environmental protection actions may also be determined and applied at the autonomous community level. Spain is divided into autonomous communities ("comunidades autónomas"), which are in themselves composed of provinces. Overall, there are 17 autonomous communities in Spain and 52 provinces. A very important risk is a change in political control, whether it is to the right or to the left wing, as this may affect the continuation of the funding of conservation projects. This is very much applicable to the bycatch project for example, as the project was partially funded by the Biodiversity Foundation (Fundación Biodiversidad), which comes under the Spanish environmental ministry. However, as noted by the president of the project holding organization, "We are working with protected species under Spanish regulations, international European Community agreements, the IUCN, protected by CITES or regulated by CITES international trade agreements. In other words, the situation of marine turtles encompasses a whole host of management and protection measures that are global, because they are not exclusively from specific countries or regions" (Chelonia president. February 2019—(Bulmer and Del Prado-Higuera 2021a)). Hence, it is highly unlikely that the Spanish Environmental Ministry will seek to alter the sea turtles' conservation status established by the IUCN, nor that a political change will affect the project's continuation (Bulmer and Del Prado-Higuera 2021a).

Marine Conservation Project 2—Bottlenose Dolphin Conservation Project in Normandy, France

According to the IUCN, the Common bottlenose dolphin (*Tursiops truncatus*) presently has a "vulnerable" conservation status. The species has been noted to be capable of adapting easily to human-driven environments. For example, dolphins often inhabit coastal waters where they come into close contact with anthropogenic activity. Over time, *T. truncatus* have come to learn how to obtain fish from trawls, gillnets, and fish cages, behavior which has, unfortunately, made them partially dependent on human activity. The consequences of the latter are that dolphins are often by-caught in fishing nets, which leads to considerable mutual reproaches between the fishermen and scientists. Bottlenose dolphins may also show a general sedentary behavior, with limited movements not exceeding a diameter of more than 80 km. This is the case for the Normand-Breton bottlenose dolphin population.

The Normand-Breton Gulf has a long history of commercial fishing, most of which is essentially coastal. Fishing units are small and versatile and are mostly present in the maritime districts of Cherbourg, Saint-Malo, and Saint-Brieuc (Bulmer and Del Prado-Higuera 2021b). Shellfish fisheries are paramount in the Normand-Breton Gulf, with Granville being the main fishing port in Lower Normandy. Fisheries specializing in cuttlefish, and large crustaceans have also been well-developed in the area.

Furthermore, there are several renewable marine energy projects, the economic viability of which is being studied in the area, namely two wind farms in the Seine Bay and the Saint-Brieuc Bay, as well as a tidal farm project at Raz Blanchard (Bulmer and Del Prado-Higuera 2021b). As a result of this commercial development activity, there is a reciprocal determination on the part of the GECC, the NGO dedicated to the conservation of the bottlenose dolphin in the area, to protect the natural heritage of the Normand-Breton Gulf, via the creation and implementation of a marine park, whose aim will be to protect specific habitats while finding the right balance between the execution of human and commercial activities and biodiversity conservation. In this sense, the GECC is therefore carrying out the monitoring of the Normand-Breton Gulf bottlenose dolphin population to assess the effects of anthropogenic activities such as those of the renewable energy projects that are under way.

The Normandy Bottlenose Dolphin project has a very peculiar and diverse stakeholder context. The peculiarity of this situation is nurtured by four elements that are presently threatening the project, which are (Bulmer and Del Prado-Higuera 2021b):

- The potential construction of the offshore wind farms of Baie de Seine and St Brieuc.
- The pressure exerted by fishermen (i.e., both professional and recreational)
- The pressure from the tourism industry promoting whale watching activities.
- The elevated levels of pollutants found in the ocean.

The main project stakeholders are listed below and mapped out in Fig. 2 (Bulmer and Del Prado-Higuera 2021b).

- Project holder organization members (i.e., Groupe d´Étude des Cétacés du Cotentin—GECC)
- Whale-watching NGOs
- Universities
- Regional government
- National government
- Commercial fishermen
- Recreational fishermen
- Renewable energy companies
- Funders

GECC with regard to the project being presented in this chapter aims to gather, and log the maximum amount of knowledge on the Normand-Breton sedentary bottlenose dolphin population. This bottlenose dolphin population inhabits a fragile geographical location, straddling two administrative regions, Brittany and Normandy, an area that is presently not protected (Bulmer and Del Prado-Higuera 2021b). France at

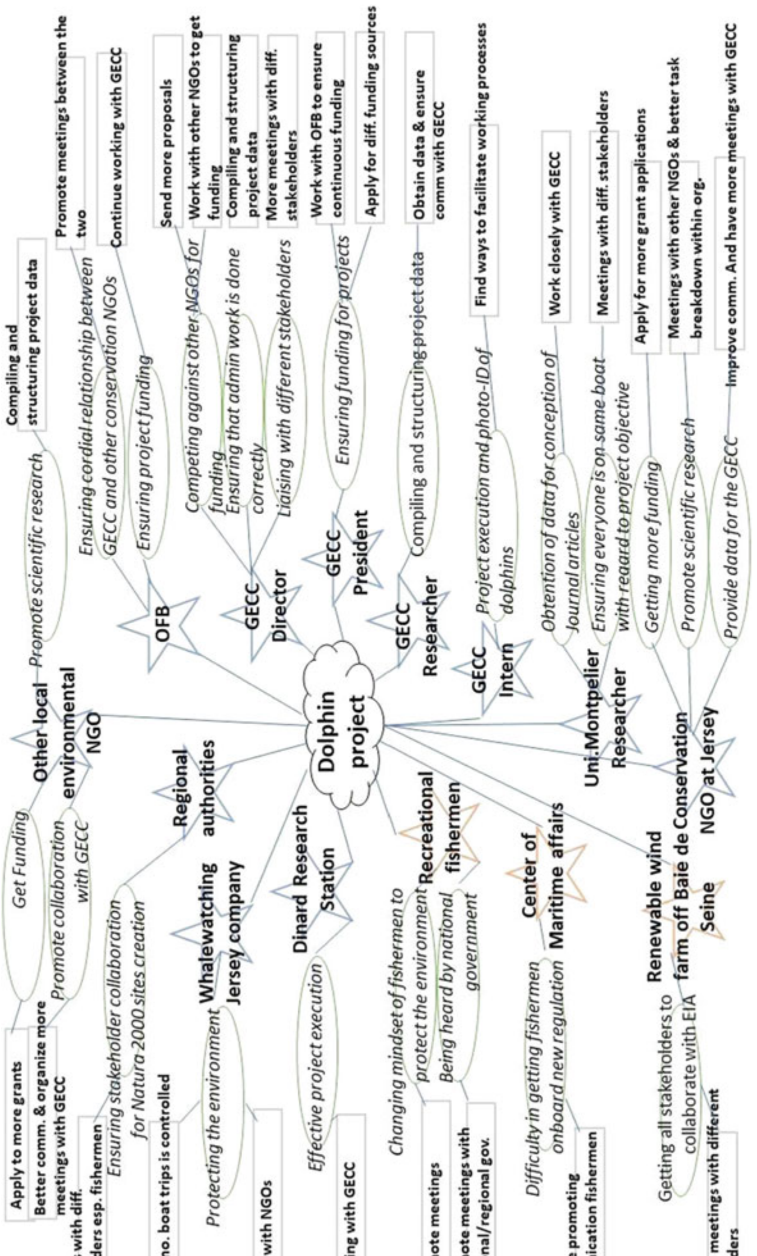

Fig. 2 Stakeholder map of Normandy bottlenose dolphin project (Bulmer and Del Prado-Higuera 2021b)

present possesses eight marine parks, the first of which was created in 2007 and the latest in 2017, and in principle ten were initially planned. There is one of these parks that were never to see the light of day, but that was meant to encompass the whole of the Normand-Breton Gulf region, which covers the area inhabited by the sedentary bottlenose dolphin population. A few years back, the two administrative regions of Normandy and Bretagne had agreed to create this marine park; however, there were regional elections, and this led to the abandonment of the protected marine park development project. This was a regretful situation as had this marine protected area been established, the whole of the Normand-Breton bottlenose population would have been protected. At present, in the region, there are only a few Natura 2000 sites, which are too small to be able to cover the whole area covered by the dolphin population and thereby ensure its conservation. The objective of the Natura 2000 sites is to evaluate and better protect marine ecosystems through the reduction of the various pressures exerted on them.

What further complicates the Normand-Breton bottlenose dolphin conservation scenario is its international context. Although the dolphin population in the Normand-Breton coast is sedentary, some dolphin movement has been observed in British waters, such as for example in some of the Channel Islands such as Jersey and Guernsey, both close to the coast of France. What has complicated the situation considerably is Brexit that came into effect on the 1st of January 2021, and the consequent legal changes (i.e., that may have affected the fishing activities and conservation activities). Because of this international panorama, two British stakeholders were included in the study; an environmental NGO in Guernsey and a tourism company in Jersey that offers whale watching as part of their business (Bulmer and Del Prado-Higuera 2021b). Both parties supported the dolphin project and were willing to collaborate in any way possible. The environmental NGO in Guernsey works alongside the GECC regarding research and provides the GECC with dolphin identification data from the British waters of the Chanel. Moreover, the tourism company in Jersey had an interest in the bottlenose dolphin remaining in the Channel as the latter contributes to its business objectives.

Although most project stakeholders supported the GECC bottlenose dolphin project, there are two stakeholders (as shown in Fig. 2) that opposed it. These were the recreational fishermen and the commercial fishermen. The recreational fishermen considered that the dolphins posed a threat and were a nuisance to their fishing activity. The recreational fishermen's associations of Normandy principally encompass retirees of an average age of 70 years who spend their recreational time fishing. A very important point to highlight is that these retirees represent a generation that does not care very much for the environment, and thereby hold a perception of nature that is contrary to that of the younger generations of fishermen. There were no fishing quotas in earlier times, and the fishermen could take as many fish as they wanted. The generalized perception of the fishermen is that if there are dolphins then that reduces the fish available for themselves because dolphins are predating upon the fish stocks in the region (Bulmer and Del Prado-Higuera 2021b). In France, strict laws have been put into place regarding the fishing quotas of certain species like the mackerel. Even though strict regulations have been implemented, there is still considerable abuse by recreational fishermen. It is thus not surprising that it has been difficult to get the Norman–Breton fishermen to negotiate in favor of the conservation of the bottlenose dolphin in the region. A further obstacle from a regulatory context is getting the recreational fishermen onboard in the process of establishing Natura 2000 sites in the area.

The recreational fishermen did not support the dolphins nor their dolphin conservation issue. They themselves had another conflict at hand and that was dealing with the professional fishermen. In an interview, the president of one recreational fishing association said that the commercial trawlers abused their rights, arguing that they took all the food from the ocean and of the whole ocean food chain. The recreational fishermen do not feel protected by present French legislation, their perception being that the central government only considered the professional fishermen, and thus they, the recreational fishermen, wanted a ban on trawl fishing.

The project holding organization "GECC" has a hefty dilemma ahead. At the project level, it will need to compile and analyze statistically the maximum amount of data to analyze and collate and then hand over to the different parties such as the French national government, so that the impact of the different anthropogenic pressures on the Normand-Breton dolphin population may be measured, and thus endeavor to promote preventive and corrective initiatives in order to ensure the preservation of the species.

The renewable energy projects in the region are further confounding the situation for the GECC and the Norman–Breton bottlenose dolphin conservation project. Energy producers have been interested in establishing projects in the Norman–Breton Gulf region since before the turn of the century. The attraction of the potential for developing marine renewable energies in the region has led to proposals for offshore wind turbine projects in the Saint-Brieuc and Seine bays as well as the development of a tidal farm project at Raz Blanchard. The Baie de Seine Environmental Impact Assessment (EIA) Project Manager was interviewed for this study. This offshore windmill project spans 10,500 km^2, 8075 km^2 of which are in the Baie de Seine, which coincides with the bottlenose dolphin population area. Nonetheless, there is a considerable degree of uncertainty as to how exactly the turbine sound levels will affect the dolphins. Part of the EIA was to determine the impact that the wind turbine vibrations would have on marine life, such as the fish stock, shellfish, and marine mammals (i.e., specifically the dolphins). There is presently a considerable lack of knowledge in this respect.

The Norman–Breton bottlenose dolphin project is an example of a multi-actor governance context that is proving very difficult to resolve. The mission of the project is clear; however, there are many interests at stake (i.e., listed below), and the GECC has a great challenge ahead (Bulmer and Del Prado-Higuera 2021b).

- The implementation of the wind farm projects in the region.
- The opposition from both recreational and professional fishermen
- The project's international context, which may have legal implications due to Brexit.

Conclusion

According to Callon (Callon 1986; Callon and Latour 1981), the definitions and roles of the different actors in a project cannot be cut off from their relationships. Hence, the notion of a stakeholder mapping exercise was key to understanding a project's stakeholder relationships. Stakeholder mapping was carried out for both case studies presented in this chapter. In the stakeholder mapping exercise, stakeholders may be identified as supporters or opponents to the project mission, as well as the potential problems that each of these may have experienced regarding the project's realization.

The studies analyzed were used to show how a multi-actor governance can be successful in attaining a project's objectives and to illustrate how the SDG 17, Partnership for the Goals could be potentially used to promote SDG 14, "Life Under Water". Although these case studies are specifically applicable to a marine conservation context, they may be extrapolated and applied to any other SDG context (Bulmer and Del Prado-Higuera 2021b).

Although it can be difficult to define stakeholders in the SDG context, SDG 17 helps to; (1) ensure stakeholder collaboration, (2) identify the obstacles that may affect stakeholder engagement, (3) develop a multi-actor network. This approach will permit a more efficient prioritization of the issues to be dealt with in the project and the development of more efficient strategies on how to integrate and better engage the different stakeholders in the project.

Multi-actor governance approaches are more efficient than traditional ones, producing fairer and more stable solutions compared to decisions that are taken unilaterally. Hence, project actors should participate at the various administrative levels nationally and internationally. At each of these levels, all stakeholders need to develop agreements to guarantee that the multi-actor governance context is preserved.

Most public collective governance initiatives are based on promoting transparency, accountability, and participation among a realm of different project actors. These three elements are crucial to enhance governance at all levels. In this respect, the seventeenth SDG is advantageous in encouraging global alliances and multi-actor governance in an interconnected world between national and local governments, companies, civil society, and academia. The Valencian marine turtle and the Normandy bottlenose dolphin conservation projects that were analyzed in this chapter are excellent examples of this. Marine conservation entails no earthly boundaries and a multi-actor governance involving a realm of different parties is essential to assure the successful execution of conservation projects worldwide.

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M. L. De Lázaro Torres and R. De Miguel González (eds.), *Sustainable Development Goals in Europe*, Key Challenges in Geography,
https://doi.org/10.1007/978-3-031-21614-5

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