16 The Challenges of the Food, Water, and Energy Nexus and Potential Interlinkages with Instruments to Tackle Climate Change: Cases of Brazilian Cities

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Abstract

The key actions to advance knowledge about sustainable and resilient urban governance are identifying and analyzing innovative initiatives for managing the food, water, and energy nexus (FWEN) in cities. Rapid urban changes in the world's cities are placing unprecedented demands on energy, water, food, and other systems, as each of them offers multiple life-supporting services. Identifying intersections across a diverse set of social actors and institutions represents a relevant agenda that can influence priority outcomes to urban communities, city regions, and their supporting ecosystems. It can be seen as a relevant strategy to advance toward a more integrated territorial planning in cities to strengthen actions to promote sustainable use of natural resources. These drivers have the potential to foster collaborative, functional, and transformative responses in the contexts of an institutional interplay, aiming to encourage co-management, bridging organizations, and social entrepreneurship among other stakeholders. From this background research, the chapter then presents the cases of the Brazilian cities of São José dos Campos and Florianópolis within the context of the "IFWEN – Understanding Innovative Initiatives for Governing Food, Water and Energy Nexus in Cities" project – as a basis to

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discuss this integrated perspective. The cases of São José dos Campos and Florianópolis illustrate, respectively, how actions on the FWEN for environmental protection and organic food production can contribute to the debate regarding innovation in urban governance and potential nexus enhancement. Due to the need to keep improving municipal planning, governance, and implementation of effective measures, a discussion is conducted regarding the potential of Local Climate Action Plans to increase the integration among sectors and actors. These insights arise from the cases of Recife and Fortaleza and their experience to tackle climate change and indicate that it might be possible to also foster the FWEN and enhance integrated governance at the municipal level. Moreover, this chapter also addresses insights from the cities of Recife and Fortaleza in Brazil regarding climate change adaptation and mitigation, focusing on their Local Climate Action Plan update under the "Urban-LEDS Phase II" project. These plans might be a strategic tool to foster FWEN and more integrated governance.

Keywords

Local Climate Action Plans · Integrated governance · Adaptation · Mitigation · FWEN

16.1 Introduction and Context

According to the World Economic Forum's (WEF) Global Risks Report (2021), climate action failure continues to be one of the main highest impact risks of the next decade, together with environmental risks, as well as weapons of mass destruction, livelihood crises, debt crises, and IT infrastructure breakdown, even though infectious diseases are in the top spot (WEF, 2021).

The current COVID-19 global pandemic, which is placing unprecedented impacts in so many countries and cities (Deslatte et al., 2020; Douglas et al., 2020; Harari, 2021), clearly reinforces planetary interdependence processes that can result in distinct scales of risks around the globe (Fortes & Ribeiro, 2014). Issues, such as the rapid loss of biodiversity in cities, should be considered as part of the need to connect variables that link water- and foodborne diseases and zoonosis (Dasgupta, 2021). The Organization for Economic Co-operation and Development (OECD) in "building back better" pandemic recovery plan highlights the need to invest in sustainable environmental management practices and conservation and restoration projects, as it can help prevent future pandemics and foster resilience and socio-environmental innovation in cities.

Fragmentation, technical-administrative barriers, political disputes, social polarization, and economic interests, among others, are components that bring even more complexity to the development and implementation of strategies to reduce potential negative risk impacts (Moran, 2011; Beck, 2018). According to Beck (2018, p. 15) "we live in a world that is not only changing but is metamorphosing, and this implies that some things change while others remain static." Thus, the concept of metamorphosis implies the destabilization of certainties of modern society. In current times, global risks create new forms of communities, and the public is increasingly intertwined by globalization. These in turn make global risks visible and political, as is the case of the COVID-19 pandemic. Within this changing reality, complexity demands the strengthening of hybrid scientific objects; the breaking down of knowledge boundaries, and hierarchies of knowledge, which is effective through cross sections and collaborative dynamics, as it challenges advances in disciplinary boundaries; and fertilizing exchanges, to promote awareness for change and uncertainty (Jacobi et al., 2020).

Urban areas can account for around 70% of CO_2 emissions from global energy use (Seto et al., 2014). Hosting more than half of the world's population, cities concentrate most of the built assets and economic activities, reinforcing their vulnerability to climate change. Impacts caused by climate changes are already being felt in urban areas and have been increasing in recent years, such as rising temperatures, rising sea lev-

els, heat islands, floods, water and food shortages, and extreme events. Most Brazilian cities also face challenges associated with patterns of development and urban expansion (Klug et al., 2016). Changes in the hydrological cycle by global warming tend to accentuate these existing challenges and risks, such as floods, landslides, heat waves, and drinking water supply (PBMC, 2016).

Evaluations of these interrelationships between systems and complex problems, such as climate change, pandemics, and so many social challenges, are not simple, especially for the management of urban areas. However, some approaches reinforce that to seek better solutions to complex problems, it is important to consider broad, systemic, interdisciplinary, multisectoral, and participatory aspects, such as the concept of the water-energy-food nexus (Schulterbrandt-Gragg et al., 2018).

Under the Brazilian context, the Ministry of Regional Development is currently developing the National Policy of Urban Development, which aims to provide a more strategic vision of the diverse Brazilian territory, adopting a multilevel, inter-federative, inter-sectoral, and interinstitutional approach, and a systemic perspective, which incorporates cross-cutting themes and dimensions of economic development (Bruno, 2020). It is also important to mention some of the main planning and management instruments already established by national laws, which have potential linkages with water-energy-food nexus, such as the Municipal Master Plan (Plano Diretor), Municipal Sanitation Plan, Municipal Urban Mobility Plan, Municipal Plan for Disaster Risks Reduction, *Mata Atlantica* Municipal Plan, and Municipal Housing Plan of Social Interest. Even though national laws do not establish them, some Brazilian municipalities further approve specific municipal laws or instruments to develop and implement plans that can support to tackle local challenges, such as the Municipal Sustainability Development Laws, Food Security Laws, Urban Forestry Plan, Water Security Plan, Payment for Environmental Services Municipal Laws, Energy Efficiency Plan, and Local Climate Action Plans (LCAP), among others (CNM, 2014; Costa & Favarão, 2016). Regarding the LCAP, this chapter considers insights from two Brazilian cities' recent experience – Recife and Fortaleza – related to the development of their Local Climate Action Plans, especially in terms of the potential to strengthen the possible synergies between municipal sectors and increase co-benefits and nexus logics. All initiatives present a direct engagement of ICLEI – Local Governments for Sustainability – which provided access to the content development.

The interlinkage reflections consider if the FWEN can be increased through climate change planning instruments at the local level – since these instruments might present a potential to overcome some sectorial barriers and find innovative and more inclusive approaches to increase an effective and more efficient overlap between sectors aiming to enhance the co-benefits for social-environmental aspects.

In the section that follows, we present the study cases of two Brazilian cities – Florianópolis and São José dos Campos – under the nexus logic. Both cases present a stronger focus in one specific nexus' sector and also great potential to scale up the integration with other sectors and especially under a more integrated municipal governance. Then a discussion, based on the reflections and insights from the Local Climate Action Plans' experiences and background research and analysis, is presented. This chapter is focused on presenting and investigating specific empirical examples, focusing on the nexus governance in resource provision at city levels, if potential synergies can be fostered by the climate change agenda, considering different scales, from the global and national into regional and city levels.

This chapter contributes to scientific investigations which aim to identify ways to improve the nexus at the Brazilian municipal level and the potential enhancement of results that can arise from the "nexus approach," according to the description of the editors of this book – as multidimensional means that seeks to understand the interrelationships and interdependencies between water, energy, and food with climate change, taking into account complex and nonlinear aspects.

16.2 Evaluation of Two Brazilian Nexus Case Studies

This chapter was based mainly on the case review, analyses, and cross-check with literature. In this section, especially the cases of Florianópolis and São José dos Campos developed under the IFWEN project were further described to evaluate if the water-energy-food nexus is already being applied at their specific initiatives.

The "IFWEN – Understanding Innovative Initiatives for Governing Food, Water and Energy Nexus in Cities" project – is a two-year project (2019–2021) financed by the Belmont Forum, JPI Urban Europe e EU Horizon 2020. And it is implemented by the Fundação Getúlio Vargas (FGV); Yale University; ICLEI, Local Governments for Sustainability; The Nature of the Cities (TNOC); Stockholm Resilience Centre (SRC); Ming-Chuan University (MCU); and MIT CoLab.[1]

The IFWEN project has the following key objectives:

1. Assessing the changes in trade-offs of food-water-energy nexus (FWEN) in the Green and Blue Infrastructure (GBI) and their association with spatial planning and governance in cities using empirical cases.
2. Understanding the barriers that hinder innovative and integrated FWEN approaches using GBI at different scales and specifically looking for the standard features of diverse interventions, as well as how successful GBI-based innovations that changed the nexus took place, which capabilities cities had to innovate and how they develop those capabilities and approaches used to overcome the barriers that make the implementation more difficult in practice.
3. Designing a framework, a guide of best practices, and tools to foster IFWEN using GBI with better urban interventions and decision-making processes (Fig. 16.1).

[1] https://ifwen.org/what-it-is-ifwen/

The project has case studies in eight cities across three regions (South America, Africa, and Asia): Antananarivo (Madagascar), Dodoma (Tanzania), Florianópolis (Brazil), Gangtok (India), Johannesburg (South Africa), Lilongwe (Malawi), Nagpur (India), and São José dos Campos (Brazil). This chapter will focus on the discussion in the Brazilian cities – Florianópolis and São José dos Campos cases – especially concerning the work led by ICLEI South American Secretariat. To analyze these contexts and consolidate study cases, the methods applied included surveys, interviews, field visits, literature reviews, and desktop research.

The surveys were applied in an initial phase of the research, before the conduction of interviews. They included questions regarding the panorama of the city, such as its jurisdiction, geographic, socioeconomic, demographic, financial aspects, and legal and institutional matters that affect the FWEN. The surveys were answered separately by each city through an appointed representative who acted as a focal point within the municipality to gather the requested information from different departments and areas of expertise.

Regarding the interviews, these were conducted with the focal point and representatives for each municipality after the survey application to deepen the knowledge on the city's context and innovation initiatives on the FWEN. Questions included inquiries on the municipal departments involved with the nexus and GBI, key local challenges, identifying the innovative initiatives and enabling capabilities that allowed for the nexus, and knowledge management mechanisms on the thematic. The interviews were conducted both virtually and in person, in the latter case enabling site visits to better understand the city context and the specific innovative initiatives identified.

The description and evaluation that follows from both Brazilian cases consider that the nexus concept challenges existing structures, sector policies, and procedures to innovate traditional silo thinking and promote new dynamics of coordination. It is necessary to modify the prevalent logic based on "divided responsibilities that often result in poorly coordinated investments, increased costs and underutilized infrastructure

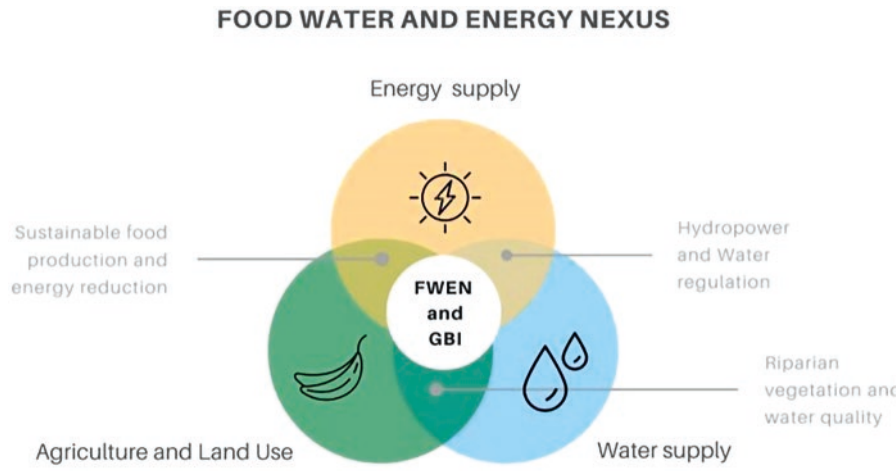

Fig. 16.1 Examples of GBI in the FWEN in the City of São José dos Campos. (Source: Elaborated by the authors within the IFWEN project work)

and facilities" (BMZ, 2014). The great challenge is to connect policies, practices, organizations, and institutions to work together horizontally and vertically to optimize resource use (Hezri, 2016). This requires capacity and institution-building on multiple levels to strengthen articulated governance with connectivity and integration of resource systems by shedding light on the possible synergies or trade-offs that might exist between different resources (C. Zhang et al., 2018).

16.2.1 Florianópolis, State of Santa Catarina, Brazil

16.2.1.1 Context

Florianópolis is located in the southern region of Brazil and is the capital of the State of Santa Catarina. Its population is mainly urban (96.21%) estimated at 492.977 inhabitants in 2018, the 17th densest capital of Brazil with 627.24 hab./km^2 (IBGE, 2010a, b). The city is highly dependent on resources from the surrounding municipalities in the continent, which implies less efficiency and more complex processes, especially regarding FWEN and the trade-offs between these services, the nexus. Dependence from metropolitan/regional and federal spheres of government to support the supply of FWEN in Florianópolis is a central challenge faced by the city. For instance, the leading electric energy supplier of the municipality is the *Centrais Elétricas de Santa Catarina* (CELESC), the company responsible for powering the State of Santa Catarina and 92.7% of the households in Florianópolis (BID et al., 2015). As well as power, water resources are also majorly provided to the city from continental sources by the Catarinense Company for Water and Sanitation (Companhia Catarinense de Água e Saneamento – CASAN). Food provision also heavily depends on continental sources – food production makes up less than 1% of the local economic activity, and the 22 municipalities that constitute the Florianópolis' Metropolitan Nucleus provide Florianópolis and for that are known as the "Green Belt." Tourism contributes to the economy of the city; this activity pressures the FWEN distribution net and accelerates the importation rates of resources to the city, as well as waste production.

16.2.1.2 Florianópolis Case Study

The case for the Florianópolis context was organized through semi-structured exploratory interviews and analysis with the city technical focal points to identify innovative approaches related to the FWEN (at least one sector as strong components). Also, the case should demonstrate a

potential for GBI positive impacts and should be associated with municipal planning instruments and governance within the city. It consists of initiatives especially regarding the Municipal Urban Agriculture Program (MUAP – Programa Municipal de Agricultura Urbana). This program was established in Florianópolis in June 2017 through a decree,[2] to promote urban agroecological practices to produce and process food efficiently and locally, incentivizing access to healthy and low-cost food produced with agroecological methodologies within the urban context. Also, the MUAP aims at supporting local organic food producers to commercialize products directly, reducing production chains and transportation requirements. By doing so, the project envisions enhancing the co-benefits from these practices, such as repurposing land use within the urban context, maintaining clean and illegal littering of accessible urban areas, and promoting community participation and engagement (CEPAGRO, 2016).

The *Revolução dos Baldinhos*, "Bucket Revolution," was also key for triggering this initiative. In 2008, professionals from the Health Center in the Monte Cristo neighborhood, one of the most vulnerable and poor areas in the continental portion of Florianópolis, assembled with the *Centro de Estudos e Promoção da Agricultura de Grupo* (CEPAGRO) and local school and nursery representatives to discuss strategies for facing disease-spreading pests and illegal littering (of mainly organic materials) that caused it. This initiative has generated a net of workers responsible for collecting organic matter from houses, processing it, and distributing the composted matter in the urban gardens of the region.

Municipality representatives have identified these successful efforts as key for developing MUAP and addressing citywide challenges mentioned above, such as independence of food production, food security, and waste management. MUAP is funded through specific project notices and receives support from the project coordinators, such as the *Companhia de Melhoramentos da Capital* (COMCAP), responsible for providing technical support for the maintenance of the gardens as wood chips for covering the composting piles and seedling. Also, the program supports the Street Fair at the *Alfandega* Square at the center of the city. This allows food producers to sell products directly to consumers, shortening production circuits and enhancing the autonomy of the municipality in food production.

The initiative has provided the city with the possibility to reuse organic waste by composting the material and repurposing it as fertilizer for organic urban gardens. By doing so, the city has achieved (1) greater independence for food production at the local scale, increasing food safety and security, (2) greater independence for waste management, and (3) less waste destined to landfills (Florianópolis was a pioneer city on this aspect, being the first Brazilian city to approve a municipal law in 2019[3]). These direct impacts could potentially generate associated co-benefits, such as the following:

1. Reduction of GHG emissions due to a smaller volume of food input to landfills and reduced transportation of food from the continental to the insular portion of the island.
2. Increased water quality and quantity due to reduction on landfill by-products reaching aquifers:
   2.1. More permeable surfaces on urban centers reducing flooding events.
3. Reduced energy use due to the shorter production chain.
4. Qualities provided by urban green areas, such as better air quality, water infiltration, and micro-climate regulation, and provision of habitat for urban fauna.

[2] https://leismunicipais.com.br/a/sc/f/florianopolis/decreto/2017/1769/17688/decreto-n-17688-2017-dispoe-sobre-a-criacao-do-programa-municipal-de-agricultura-urbana?q=17688

[3] https://leismunicipais.com.br/a/sc/f/florianopolis/lei-ordinaria/2019/10510/10501/lei-ordinaria-n-10501-2019-dispoe-sobre-a-obrigatoriedade-da-reciclagem-de-residuos-solidos-organicos-no-municipio-de-florianopolis

In Florianópolis, the most substantial FWEN sector is related to the food sector. The case study is already an initiative focusing on food security and the improvement of local agroecological practices. More linkages were identified between water and energy sectors, such as related sustainable local food production leading to water quality maintenance and reduction in energy demand due to optimization of production chains and transportation. A direct link with all the three nexus sectors was not identified. It is also important to highlight that waste, although not a sector of the FWEN, appears as an important component, in this case, fostering the use of organic compost for gardens and agriculture under circular development principles and avoiding organic waste in landfills.

The image below represents the interlinkages and preponderance of nexus sectors related to Florianópolis analysis (Fig. 16.2).

16.2.2 São José dos Campos, State of São Paulo, Brazil

16.2.2.1 Context

São José dos Campos (SJC) is located in the eastern portion of the State of São Paulo, and it is the main municipality in the Metropolitan Region of *Vale do Paraíba*. The Paraíba Valley is situated between the cities of São Paulo and Rio de Janeiro and stands out for concentrating a considerable part of the regional GDP (gross domestic product). It is also known for being the most important aeronautical and aerospace hub in Latin America and hosting important federal scientific research institutes, technology companies, universities, colleges, and training centers to develop labor skills. Due to these aspects, the city is considered a hub of innovation in the region. In the Brazilian context, even though SJC is the fifth most populous city in the State of São Paulo with 629.921 people (2010) (IBGE, 2010a, b), the population density of the municipality is small compared to other large urban centers in Brazil. SJC is situated in a privileged area within the State of São Paulo that allows access to water sources – both for supplying the population and with hydroelectric potential – and to floodplains used for food production. Still, the development and urbanization history of the city have been heavily dependent on the nearby centers – São Paulo and Minas Gerais – and resulted in a profound dependence of São José dos Campos on important food, water, and energy. Also, enlightening the nexus between these elements and tracing more efficient technologies and policies to do so are a central challenge.

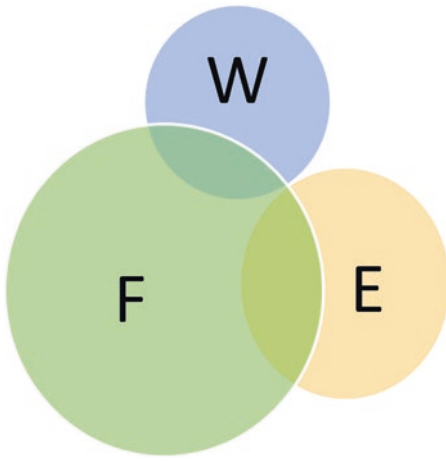

Fig. 16.2 Current integration and preponderance of nexus sectors from the Florianópolis study case. (Source: Elaborated by the authors)

Although the city does not have programs or policies explicitly aimed at the FWEN, SJC was chosen for this study due to the initiatives that indirectly target this nexus. The initiatives that have the most potential to generate a positive impact in this area are the incentives for innovation (such as the recently built innovation center and the municipal law to encourage innovation), the protected areas of the municipality, and the programs for environmental compensation.

16.2.2.2 São José dos Campos Case Study

The municipality of São José dos Campos has some relevant examples of developing programs and initiatives that explore and enhance its geospatial potentials, aligning conservation with technological development in public programs undertaken regarding FWEN elements. Also, the

city has invested in projects that employ the potential of reforestation and conservation as GBI, an innovative strategy within the public arena in Brazil. Among these strategies existent in SJC toward a self-sufficient, technological, and sustainable city are portrayed below, two are included in this chapter, and were selected for deeper analysis within the IFWEN project through semi-structured exploratory interviews and analysis with the city technical focal points, due to their innovative approaches in the nexus (if not possible to all three thematic with at least one as strong components), related to GBI positive impacts, and associated with spatial planning and governance in the city: (I) the Alluvial Plains of the Rivers Paraíba do Sul and Jaguari Protected Area and (II) the Municipal Program for Payment of Environmental Services – *Programa Mais Água* (More Water Program).

I. *The Alluvial Plains of the Rivers Paraíba do Sul and Jaguari Environmental Protected Area.*

This municipal protected area was established in 1984 by the São José's Municipal Master Plan (Prefeitura de São José dos Campos, 1984) and currently is also known as the Banhado Environmental Protection Area (Banhado EPA), which is a sustainable use category under the *Sistema Nacional de Unidades de Conservação da Natureza* (SNUC) – the official Brazilian set of rules and procedures to create, implement, and manage protected areas. This is an innovative policy that supported conservancy in a context of growing urbanization trends (Fantin, 2005) and that guaranteed the protection of this area of crucial ecological importance for the maintenance and provision of essential environmental ecosystem services and quality of life of citizens, within this urban center: retention and processing of sediments, water quality, erosion and silting up control, filtering of toxins and sediments, recharge and discharge of aquifers, and buffering zone for floods (Figueroa, 1996). Moreover, this is an important area for the SJC population's quality of life, promoting key ecosystem services such as being an important feature of the city's landscape and improving air quality.

Therefore, restrictions on land use in these areas directly preserve these functions, improving water, soil, and air quality and improving flood mitigation capacity. Moreover, the Banhado EPA has been categorized as a "Zone One environmental protected area" by the SJC master plan, which is a category aimed at protecting areas that occupy the margins of rivers with hydromorphic formation and that are highly and naturally susceptible to floods. This legislation also permitted that the land use in this area can be partially destined for livestock and agricultural research and production (Prefeitura de São José dos Campos, 2019), reinforcing the food pillar of the FWEN and its correlation with GBI and water.

II. *Municipal Program for Payment of Environmental Services – Programa Mais Água.*

A municipal law[4] established in 2012 the *Programa Mais Água* (More Water Program). This program aims at promoting the conservation of areas with native vegetation in São José dos Campos and encourages sustainable practices in rural areas to protect water springs in the region, seeking increased water availability. Rural landowners need to commit to the program and follow the regulations regarding conservation of native vegetation and restoration of permanently protected areas (Áreas de Preservação Permanentes – APP) as well as the adoption of sustainable models of production to obtain monetary returns according to a standardized score (Prefeitura de São José dos Campos, 2014).

It is a premise to the program that the conservation of these green areas is essential for ensuring water provision safety and quality to the city of SJC (Prefeitura de São José dos Campos, 2015). Therefore, by offering monetary incentives to the landowners in the region, the program acknowledges the many ecosystem services pro-

[4] https://servicos2.sjc.sp.gov.br/legislacao/Leis/2012/8703.pdf

vided by the preserved areas, especially as water cycle regulation systems. Despite focusing on the potential of forests as green infrastructure for water regulation, the program also presents a clear relationship with food production in the region, as the majority of the areas contemplated by the program are destined for livestock production – 60% (Prefeitura de São José dos Campos, 2017). Properties with more sustainable practices (no pesticide use and organic production) are better evaluated by the standardized tests (Prefeitura de São José dos Campos, 2015) and get a higher reward.

The content from the case of São José dos Campos is mostly related to the water sector. The initiatives focus on the environmental management of protected areas and payment for ecosystem services related to water and springs conservation. The stronger identified link is between water and food sectors since there is a promotion of sustainable practices in rural areas to protect water springs in the region, seeking increased water availability. Another relevant observation is that none of the actions presented a direct link with all the three nexus sectors.

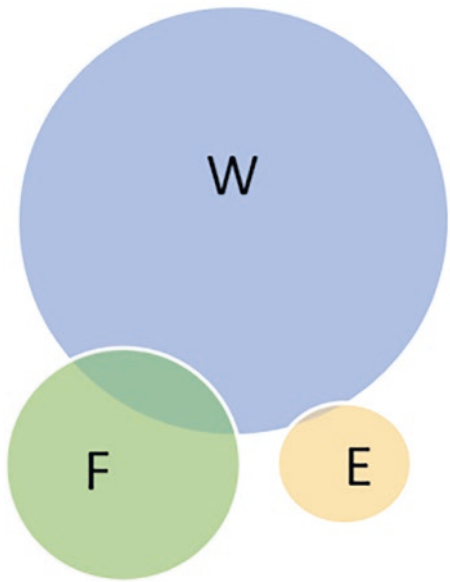

Fig. 16.3 Current integration and preponderance of nexus sectors from the São José dos Campos study case. (Source: Elaborated by the authors)

The image below represents the interlinkages and preponderance of nexus sectors related to the São José dos Campos analysis (Fig. 16.3).

16.3 Discussion

In his analysis of the WEF, Covarrubias (2021: 18) emphasizes that "the relationships for city authorities is different for either water, energy or food, because of the different geographic scales, and because of the division of governance responsibilities for each of these flows take place at different contexts." And as Covarrubias (2019) points out, this requires innovative and cross-sectorial systems of provisioning. What can be observed is that the prevailing logic is that city planning and governance still approach resources such as WEF as separate domains, ignoring their interconnectedness (Hoff, 2011; Howels & Rogner, 2014).

The nexus approach is also presented as a governance scheme that proposes a broader dialogue between stakeholders aiming to balance the trade-offs between water-energy-food sectors (Hoff, 2011). However, Brazilian municipalities still face many challenges developing, especially implementing, more integrated municipal plans and their corresponding actions. Moreover, it is crucial to find ways to improve local planning and governance processes (Benites-Lazaro & Giatti, 2020; Cabral, 2018).

This issue of local governance fragmentation can be noticed in the cases of Florianopolis and São José dos Campos. Despite being innovative initiatives, they still focus more strongly on one FWEN component and have more autonomous characteristics, not yet integrating a range of different municipal departments and stakeholders. A holistic approach to tackling global challenges could be a way to foster the integration between distinct challenges and opportunities at the local level.

The FWEN has become an important reference to urban planning and represents a new perception (Hoff, 2011) due to its potential to promote effective adaptation (Rasul & Sharma, 2015; Gondhalekar & Ramsauer, 2017) and inno-

vative urban development. Considering the effects of climate change on increasing demands for natural resources and insecurities in water, energy, and food supply, it is imperative to avoid failures in management and governance strategies (Fernandes Torres et al., 2019).

Despite not being a legal obligation for Brazilian municipalities, local leaders have become more aware that urgent efforts are required to scale up climate action, dealing with climate change mitigation, adaptation, and resilience (Arikan et al., 2020), and are developing local instruments to tackle climate change.

So far, most efforts by cities to respond to climate change have focused on mitigation (i.e., reduction of greenhouse gas emissions (GHG)) and much less on adaptation (i.e., strategies to reduce exposure and susceptibility and improve the coping capacity of communities to hazards) as these strategies imply taking a precautionary and anticipatory approach (Broto & Bulkeley, 2012; Torres, 2020; Neder et al., 2021, Di Giulio et al., 2017; Di Giulio et al., 2018). However, the implementation of adaptation plans is urgent. Changes in global climate are already underway, and social, infrastructural, and economic costs of inaction are high (Geneletti & Zardo, 2015), directly affecting water-energy-food sectors.

Aiming to increase local climate actions, the Global Covenant of Mayors for Climate and Energy (GCoM) is one of the largest movements engaging municipalities in this agenda. This global alliance for city climate leadership has raised the commitment of over 10,000 cities and local governments that share a long-term vision of supporting voluntary action to combat climate change. Cities that join the GCoM should advance with their specific climate compliance: pledge to develop a greenhouse gas emission inventory and assess climate risks and set measurable emission targets, ambitious climate adaptation goals, and sustainable energy access goals in line with the Paris Agreement. Signatories agree to formally adopt plans and targets within 3 years of signing the commitment (GCoM, 2021). The Urban-LEDS project is one of the global initiatives that directly contributes to GCoM, collaborating to achieve climate compliance. And in Brazil, it provided specific support to Recife and Fortaleza to develop their current Local Climate Action Plans, connected to their respective municipal laws.

Besides the methods applied within the IFWEN project scope for both Brazilian cases, aiming to find instruments that can support Brazilian municipalities to enhance their planning and governance strategies, an exploratory question was elaborated: can municipal instruments to tackle climate change increase the interconnectivity of specific water-energy-food sectors at the local level?

For this specific purpose, additional literature review and qualitative analysis were conducted on the topics of climate change adaptation and mitigation, focusing on the experience of two Brazilian cities – Recife and Fortaleza – which used the same methodology to update their Local Climate Action Plan under the Urban-LEDS Phase II project.

The Urban Low Emissions Development Strategy (Urban-LEDS) addresses integrated low-emission and resilient development in more than 60 cities in 8 countries: Brazil, India, Indonesia, and South Africa (from Phase I) and Bangladesh, Colombia, Lao PDR, and Rwanda (added in Phase II). In Brazil, selected cities, such as Recife and Fortaleza, received tailor-made guidance and capacity building to consolidate or develop comprehensive Urban-LEDS and integrated climate action plans using ICLEI's GreenClimateCities (GCC) methodology. The project is funded by the European Commission, coordinated globally by the Climate Change Planning Unit of the UN-Habitat, and implemented by the ICLEI – Local Governments for Sustainability.[5]

In this section, considerations were made in terms of the Florianópolis and São José dos Campos cases described previously, and discussions regarding potential interlinkages with planning instruments to tackle climate change were raised, using examples from Fortaleza and Recife.

[5] https://urban-leds.org/

This combined process resulted in the analysis and discussion presented in this chapter.

16.3.1 Insights from Local Climate Action Plans as a Tool to Increase the Nexus Potential

Aware of the fact that climate change can affect different aspects of the municipal dynamics, especially emphasizing the existing challenges, Recife and Fortaleza updated throughout 2020 their Local Climate Action Plans (LCAPs), having as the main goal the neutralization of GHG emissions by 2050 and improvement of their citizens' life quality (ICLEI, 2020a, b).

The LCAPs demonstrate how the city strategically plans to reduce GHG emissions and adapt to the consequences of climate change. It aims to provide an alignment between sectors and municipal departments, existing legislation, planned projects, and actions. It is an executive, instrumental, and dynamic document that presents the city's level of ambition in planning climate change mitigation and adaptation (ICLEI, 2020a, b).

The process to develop the plans is part of the GreenClimateCities (GCC) methodology, composed of nine steps in three phases – analyze, act, and accelerate – outlining how climate risks and vulnerabilities can be assessed and options (to achieve low-to-no emission development and climate adaptive development) can be identified and integrated into urban development policies, plans, and instruments. It is also associated with measuring, reporting, and verification (MRV) logic and consists of a wide range of resources, tools, and guidance to support local and regional governments to deliver ambitious climate action.

The plan is further based on UN-Habitat's guiding principles which state that climate action plans should be ambitious, inclusive, fair, comprehensive, integrated, relevant, feasible, evidence-based, transparent, and verifiable (Un-Habitat, 2015).

Taking into account the guidelines of the GCC methodology and the UN-Habitat's principles for climate action plans, relevant actors from both cities' public sector and civil society were identified to contribute to the plan development directly.

The main steps for the content of both cities' plan development were the following:

(a) Analysis of legislation in place at the city, state, and national levels related to climate aspects.
(b) Identification of existing commitments, sectoral plans, instruments, and other documents that demonstrate the city's commitment to the climate agenda.
(c) Interviews with public managers and officers, representing the following sectors/departments: urban planning, infrastructure, finance, education, transport and mobility, sanitation, housing, and environmental and urban services.
(d) Evaluation of GHG emission scenarios through municipal emission inventories (using the Global Protocol for Community-Scale GHG Emissions – GPC methodology). The most recent emission inventory results were defined as the baseline for the projection of future emission scenarios. Evaluation of the municipal climate risk assessment, which identifies the main climate hazards and potential social impacts, is also presenting projection under future scenarios.
(e) Meeting with representatives of Recife and Fortaleza's youth leaders, to collect perceptions and suggestions from the different realities of the city, contributing to the refinement of principles and actions.
(f) Organization of participatory workshops and formal meetings with Sustainability and Climate Change Municipal Committees – COMCLIMA, GECLIMA, and FORCLIMA – in addition to representatives from academia, the third sector, civil society, and the private sector to present, prioritize, and validate the main actions to be considered by both plans (ICLEI, 2020a, b).

Four strategic axes were defined as priorities for mitigation and adaptation to climate change

in both cities, detailing the goals, targets, actions, and results aiming to achieve the ambitious scenario outlined according to the baseline and strongly avoiding the business-as-usual (BAU) scenario. The four axes are energy, sanitation, mobility, and resilience (ICLEI, 2020a, b).

Analyzing these four main axes defined as priorities to tackle climate change at the municipalities' jurisdictions, its related goals, targets, and actions defined under both LCAPs present considerations for a specific question: can municipal instruments to tackle climate change increase the interconnectivity of specific water-energy-food sectors at the local level?

16.3.2 Can Municipal Instruments to Tackle Climate Change Increase the Interconnectivity of Specific Water-Energy-Food Sectors at the Local Level?

The information was organized from Fortaleza and Recife, under a table that brings together the main sectors of nexus (water-energy-food) and LCAP axes (energy, sanitation, mobility, and resilience).

The analysis only used the information available in the documents, and any interpretation of further reflections was made in terms of potential results or unfolding that could result from concrete implementation:

- In Table 16.1, the specific content of the goals, targets, and actions, specified under Recife and Fortaleza LCAPs, of energy, sanitation, mobility, and resilience is presented in the lines and located under the corresponding "nexus column." Merged cells represent a content that corresponds to two nexus sectors.

The organization of the content from the goals, targets, and actions established under the four axes of the LCAPs from Recife and Fortaleza (energy, sanitation, mobility, and resilience) allowed visualization of the linkages with the water-energy-food nexus sectors. Only the content related to at least one sector of the nexus was inserted in the table.

The outcomes show that most of the contents is related to the water sector. The majority of the identified linkages are between the water and energy sectors. This might be related to one of the main goals of the LCAPs which is the neutralization of GHG emissions by 2050. Another relevant observation is that none of the actions presented a direct link with all the three nexus sectors. It is important to note that the analysis only used the information written in the documents.

The image below represents the interlinkages and preponderance of nexus sectors related to Recife and Fortaleza analysis (Fig. 16.4).

Two actions that already present a link between two nexus sectors were chosen, from Recife and Fortaleza Local Climate Action Plans, to evaluate if possible results, or unfoldings related to concrete implementation, could provide further reflections on the three nexus sectors integration. The examples are shown here:

- Implementing ecological sanitation measures, such as biological treatment micro-station or constructed wetland, can generate organic waste/elements that could be used to produce compost for community gardens and agroforestry, among others, which would then link also with the food sector.
- Implementing low-impact development (LID) measures for water management in urban watersheds to reduce the speed of rainwater runoff, increase water infiltration into the soil, and provide alternative sources for non-primary uses. These could reduce the consumption of energy related to water or wastewater pumping and/or increase water availability in reservoirs for energy generation, which would then link also with the energy sector.

Following this exercise, one action was chosen from Florianópolis and São José dos Campos cases, which already present a link between two nexus sectors, to evaluate if potential results, or unfoldings related to concrete implementation,

Table 16.1 Analysis of Recife and Fortaleza regarding the FWEN sectors and Local Climate Action Plan axes

Nexus sectors				
		Food	Water	Energy
Local Climate Action Plan Axes	Sanitation	Install, by 2024 (Rec and For), composting plant(s) with targeted products for community gardens and/or organic agriculture, and schools, associating with environmental education initiatives	Universalize sewage services with the assurance that the treatment of wastewater is carbon neutral by 2050, also increasing the use of methane for energy generation (Rec and For)	
			Implement and evaluate the benefits of other ecological sanitation measures, such as biological treatment micro-station, constructed wetland, evapotranspiration tanks, etc. (Rec and For).	
				Reduce, by 2050, waste disposal in landfills up to 50% (Rec) and 60.6% (For).
				Ensure that the methane emitted by the decomposition of waste in landfills is burned or used for energy in 60% by 2030 and 100% from 2037 (Rec) and 50% by 2030 and 100% by 2D40 (For)
	Energy		Ensure, by 2037 (Rec) and by 2040 (For), 100% of electricity supplied is from renewable sources	
				Reduce energy consumption in all economic sectors by 20% (Rec) and 27,6% (For) by 2050, compared to the BAU scenario
	Mobility		Strengthen the resilience capacity of public transport systems upon extreme weather events (Rec)	Ensure that the public transport fleet is composed of 100% electric vehicles by 2050 (For and Rec)
			Assess, by 2023, the results of the solar boat project and the potential business model for scalability (Rec)	
			Promote, by 2037, the necessary interventions to enable the navigability of the Capibaribe and Beberibe rivers (Rec)	

(continued)

Table 16.1 (continued)

Nexus sectors				
		Food	Water	Energy
	Resilience		Foster integrated water management to reduce climate risks and guarantee water security (Rec)	
			Ensure access and supply of drinking water to the entire population by 2025 (Rec).	
			Identify water bodies that can undergo revitalization and renaturalization processes by 2023 (Rec)	
			Create an Urban Water Committee to promote coordination between the institutions responsible for supply, sewage, and drainage (For)	
		Implement LIDs in urban watersheds to reduce the speed of runoff of rainwater, increase water infiltration into the soil, and provide alternative sources for non-primary uses, such as green roofs, rain gardens, bio-swales, cisterns, wetlands, permeable paving, etc. (For)		
		Promote systemic management of green areas, including afforestation, urban agriculture, municipal parks, and APPs (Rec and For)		
		Promote practices of ecological agriculture and agroforestry systems, providing technical support (Rec)		
		Recognize urban agriculture initiatives that value gender equity and cultural diversity (Rec)		

Source: Elaborated by the authors.
(For) content-specific from the city of Fortaleza; (Rec) content-specific from the city of Recife

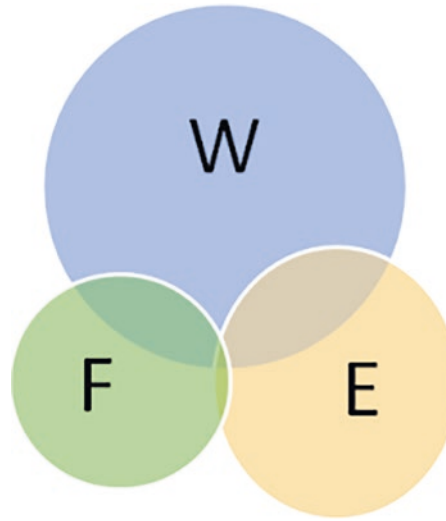

Fig. 16.4 Current integration and preponderance of nexus sectors considered under Recife and Fortaleza Local Climate Action Plans. (Source: Elaborated by the authors)

could provide further reflections on the three nexus sectors integration. The examples are shown here:

Florianópolis

- The use of organic compost for gardens and urban agriculture could also generate renewable energy through biogas and reduce waste in landfills that do not capture the methane, which would then link also with the energy sector.

São José dos Campos

- Promote sustainable agroecological practices in rural areas to protect water springs in the region; seeking increased water availability can also increase water availability in reservoirs for energy generation.

These examples above demonstrate that it might be possible to increase the integration between the FWEN sectors, through a specific GBI measure which could also be included under more cross-cutting municipal instruments, such as Local Climate Action Plans, therefore reinforcing the role of integrated instruments in promoting broader governance of municipal aspects.

The cases analyzed under this section present that the nexus logic can be enhanced in some aspects. According to the image below, one of the main potentials of the nexus approach is to increase the integration between sectors. The cases present one stronger sector – integrating with another sector, but no concrete integration between the three of them, as predicted in a high integration nexus circumstance, was identified (Fig. 16.5).

According to Covarrubias (2020), this lack of integration presents an important possibility to improve the overall sustainability performances of urban infrastructures and governance.

The innovation approaches, specifically focusing on GBI, from Florianópolis and São José dos Campos, already demonstrate some original improvements in more sustainable urban measures. These are also tackling other important specific aspects for local context such as waste management, in the case of Florianópolis, and economic mechanisms, such as the payment for environmental services to small-scale farmers in São José dos Campos.

These examples imply a clear understanding that an "urban nexus" approach assumes that socio-material flows interact and relate to one another in promoting cross-sectoral policies toward the attainment of a synergic urban sustainable development within a context of climate change. The main challenge is to overcome the prevailing logic based on addressing and formulating policies in silos that do not guarantee simultaneous attainment of WEF security as well as environmental sustainability (Bhaduri et al., 2015: 726).

Interdisciplinary approaches to urban nexus can support more collaborative efforts across sectors, scales, and jurisdictions, enabling new technical-scientific and societal capacities to anticipate changes and effectively respond to emerging risks (Sperling & Berke, 2017).

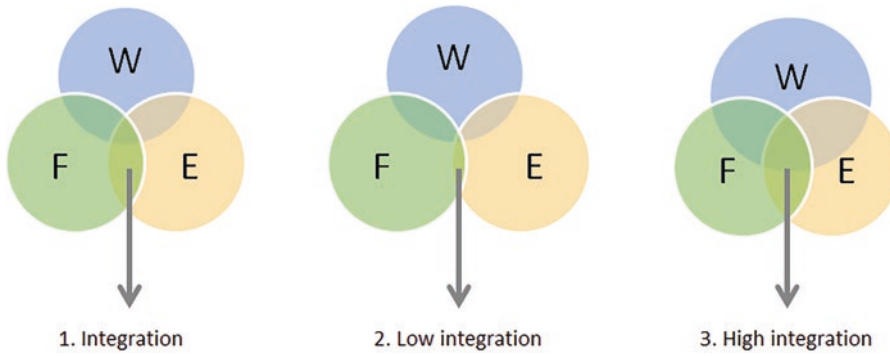

Fig. 16.5 General three types of nexus sectors integration. (Source: Adapted from Sperling and Berke 2017)

Especially with the analyses of the case from Recife and Fortaleza, the process to develop Local Climate Action Plans also presents a potential to use this multidisciplinary municipal instrument to foster this sectoral integration.

16.4 Conclusion

Municipal governments face complex challenges and can be directly or indirectly influenced by global circumstances, as explored under this chapter, especially by climate change or global pandemics, such as COVID-19. Also, facing an internal scenario in the public administration of lack of financial resources, technical capacity, mid-long-term strategic planning, traditional silo thinking, and operating, it is imperative to find better ways to improve existing dynamics.

The Brazilian cases presented in this article demonstrate improvements in parts of these complex approaches and also indicate potential ways to keep increasing more effective integration. The reflections arising from the analysis of the Local Climate Action Plan (LCAP) development methodology indicate a good potential to bring different actors, especially related to nexus sectors, to the same table to define strategic actions to tackle climate change at the local level. It is important to note that, currently, the main LCAP goals still have a stronger focus on GHG emission reduction. However, increasing the capacity to adapt to extreme weather events and improve the overall resilience of the territory, its citizens, and local systems is also an important highlight that is being considered in the recent versions of these plans. In future plans' versions, there might be more balance between mitigation and adaptation goals, tackling other nexus aspects.

An important point to be considered under the Brazilian context is that the concept associated with WEF does not recognize inequalities in access to water, energy, and food. These aspects should be considered as relevant components in building pathways in the sense of sustainability. Also, it maintains the importance associated with the demands of human needs, disregarding the pressures on ecosystems and their services that could put at risk biodiversity conservation or increase climate emergency.

Cities can be seen as nodes that demand increasing resources. It is crucial to articulate sectors, actors, resources, infrastructures, policies, and utility services to reach a satisfactory level for the provisioning of water, energy, and food. Finding ways to unite bottom-up, top-down, multilevel, multi-sectoral, and multi-actor efforts that together can improve local governance seems to be a common imperative from the nexus and climate approaches at the local level. As some cities have been experimenting, initiatives in this direction represent an innovative trend that depends very strongly on the role of local authorities. And their understanding of what is at stake by establishing an articulated and integrative network of socio-institutional agenda of transformations directed toward a more equitable and sustainable future.

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