Chapter 16
Sustainable Energy Usage in Urban and Rural Context-A Study

Sonali Vyas, Shaurya Gupta, and Vinod Kumar Shukla

Abstract Resourceful energy ingestion remains as the critical factor in terms of attainment of goals which are subjugated to sustainable enlargement besides actions which are directly associated directly with the conditions for a better atmosphere or surrounding. When considering the energy ingestion and its abstraction from varied sources, the scientists in addition to its innumerable commerce and industrialized use besides home user are considering innovative besides optimum clarifications for the purpose of upsurge efficiency and lessening the damaging after effects in terms of ingestion. All the emerging or emergent nations need to augment their renewable energy for future prospects. Effective usage of renewable sources has transformed the comprehensive policy of using fossil or coal energy to ecological renewable energy. Internet of Energy is becoming a crucial part of Internet of Things (IoT) by inculcating newer approaches with the help of adopting diverse atmospheres for energy consumptions as the energy in sensors are thereby constructing smart environments. With these kinds of sensor-based technologies, even the user behavior is also predicted as well as their behavioral outlines in terms of energy ingestion are acknowledged. However, there are many challenges like environmental changes use of information network, augmented energy expenses plus technological development. Assessment in terms of sustainable development challenges besides probable green development approaches will give feasible solutions, which are practically achievable in terms of implementation. Sustainable development significance valuation for urban metropolis will be an everlasting field in terms of development for researchers' and scientists and apparently, it is quite significant when considering the final conciliation during the enactment with administrators of city-scale expansion.

S. Vyas · S. Gupta (✉)
School of Computer Science, UPES, Dehradun, Uttarakhand, India

V. K. Shukla
School of Engineering and Architecture, Amity University, Dubai, UAE

M. A. Ahad et al. (eds.), *Enabling Technologies for Effective Planning and Management in Sustainable Smart Cities*, https://doi.org/10.1007/978-3-031-22922-0_16

Keywords Sustainability practices · Renewable energy · Energy efficacy · Energy management · Internet of energy · Ecological development

Abbreviations

IoT	Internet of Things
IT	Information Technology
EACS	Energy Administration Controller System
IoE	Internet of Energy
CO_2	Carbon di-oxide

16.1 Introduction

There are three mainstays when sustainable development is concerned and it is exemplified by manifold monetary, societal besides ecological objectives. Prioritizing amongst manifold objectives is always context and path dependent. Preceding approach and development which is centered on evidence-based research [1, 2] and has established the fact that the comparative prioritizing the goals relies on the comparative accomplishments in terms of study with respect to time and it may involve a municipal or region. Green development [3] addresses the goals in business, which supports the economic growth or social oriented growth objective. Little carbon emission can be taken in to consideration whenever green revolution is talked about as it includes the carbon release constituents, which directly affects the conservational concerns. While the considering the case of low carbon emission [4] it become quite important to classify its association with superior objective of sustainable development including the right approach in handling the evolutionary part in future prospects. While considering the database of a metropolis sector wise it gives a clear picture as in terms of a potential investment for green energy infrastructure, which again depends on overall competent expertise or technological deployment. Existing challenges in energy management act as a hindrance in achieving the optimal usage besides generation of energy in the most efficient and optimal way. Countryside or rural progress is also quite important in terms of commercial, societal besides ecological expansion of any state. There are varied potentials while considering the case in generation of sustainable income with the help of efficient and effective usage of accessible resources in a rural scenario. Technology-centered modernizations for accompanying income influence active rural participations along with keeping the environment in check. However, Internet of Things is making a momentous involvement regarding the expansion when considering the case of economic, societal besides environmental factors. Sustainability development in any field faces many technical, environmental and social challenges generally in the emerging countries. However, any low-cost technological implementation

will be the finest situation in achieving sustainable development objectives. According to the United Nations, the rural population of India is 3.4 billion as of 2014 [4]. The populace of India existing in countryside was around 83.3 Crore as of 2016 [5]. In India, roughly 70% of people are living in countryside. Rural progress is indispensable when commercial, communal, and ecological progress of a nation is thought of. Rural advancement is achievable by the infrastructure development for social growth [6]. Quality of lifespan, occupation, well- being, cleanness, besides societal situation principally rests on nontoxic consumption of water besides efficient sanitation. Many have not comprehended the essential social and civil rights in case of social expansion [7]. However, there are numerous concerns while considering rural expansion at large [8]. While considering the current situation, government is providing adequate resources for countryside expansion, still many milestones are yet to be achieved. Most of the rural regions are very far from the urban boundaries and lacking in various facilities like transport and conveyance facility. It is because of these sorts of situation the individuals from rural background found it very difficult in selling their products or goods in market. Apart from that, they face emergency at times associated with their health, besides access to primary education for their wards. Current literateness rate for the age group of over seven and beyond in India in 2011 census was 82.14% for males plus 65.46% for females [9]. Edification plays an indispensable aspect in overall progress, which sturdily affects an entity's revenue generation possibility. Even joblessness stands as one of the major issues in rural or countryside India and because of this numerous people in their youth wander themselves to urban areas [10]. Fiscal aspects plus absences or lack of income generating chances in rural segment, nonexistence of existing arrangement causes serious migration of people to urban areas. Societal aspects comprise of healthiness, edification, besides finance, which too are noteworthy reasons for migration to urban or metropolis regions [10]. Digital commerce has changed the archetype from outmoded commerce to contemporary commerce by a large difference. Benefits and shortcomings of digital commerce plus digitization procedures are now a prime concern when considering edification, establishments besides corporations. Such digitized universal tools and sustainable green technologies assist executives in implementing their concepts in real. By innovative methods, they can estimate the future of their organization, market and life to transform it to a sustainable smart green life, towns and structures. Energy segment supports the financial prudence besides contributing straight away to quality of life, which is very important in terms of accomplishing sustainability. Currently, the mainstream energy possessions are derivative of fossil fuels like oil, coal thereby leading to ongoing reduction of energy possessions and developing of hostile conservational effects. Expansion besides disposition of uncontaminated, renewable energy is imperious while considering the monetary besides ecological awareness for any republic. Renewable energy plays a key role in fulfilling forthcoming energy essentials. Decisive objective lies in all the research work plus determinations put in for reducing energy ingesting while takin in account the wellbeing of customers keeping a tab on natural resources to move towards sustainable development besides conservational protection. Contemporary Internet expertise forms a dynamic

network of energy, which helps in interconnecting of device and information exchange amongst them. Renewable energy for instance solar, wind, water, and biomass play a quite important role in sustainable development. As authors we have tried to focus on extensive conversation regarding the following points:

- The varied domain of sustainability i.e. Environmental, Social and Economical are being discussed which are quite necessary for sustainable development. The novel development must be feasible for the environment (eco-friendly), society and must be affordable by a large part of the population.
- The resources of sustainable energy are limited and it should be used wisely in terms of implementation to achieve a wider reach. Therefore, planning of sustainable energy resources is very crucial.
- It deliberates the association amongst Internet of Energy sources like smart power grid and their storage, generation apart from their users, i.e. smart meters, smart vehicles.
- There are many challenges, which needs to be addressed whilst, the efficient and effective management and usage of energy. The meeting of ISO standards, CO2 emission are some of the challenges in effective and efficient energy management.

Section 16.2 deliberates literature review regarding sustainability, Sect. 16.3 discourses varied criteria in energy planning for sustainable development, Sect. 16.4 showcases energy management in a metropolitan context, whereas Sect. 16.5 briefs about challenges in energy management in terms of sustainability and lastly Sect. 16.6 concludes with conclusion and future scope.

16.2 Literature Review

The term sustainable development was primary cited in a report printed by WCED in the year 1987. According to the report, the sustainable development is well- defined as "development which is meeting the needs without negotiating the aptitude of forthcoming age group in terms of meeting needs." International Institute for Sustainable Development [11] labelled the perception of requirement and restraint. Development Education Program under World Bank Group clarifies as the perception of harmonizing amid societal, monetary besides atmosphere objectives [12, 13] although Sustainable Development Commission stated as central of complementary transformation plus consciousness of essentials with three domains of sustainability [14]. Global Development exploration epicenter permits harmonizing social needs apart from maintaining usual resources plus ecologies [15]. In the emerging world, IoT acts as an important portion in attaining sturdier in addition to sustainable expansion. IoT is achieving countless competence plus throughput improvements in industrial republics for the emergent ecosphere. The IoT has the marvelous chance for the social and economic advancement; overlooking the potential for larger and more important influence in emerging nations can be a huge mistake [16]. Emerging nations are perfect in terms of IoT revolution: the glitches observed by the emerging world can be

varied and unknown areas to which IoT are quite applicable. Apart from it, IoT makes an important influence to expansion in societal, ecological, takin cultural aspects also in account [17]. In last few years, IoT projects are being rapidly accepted in the developing world, for the purpose of sustainability achievement. Taking an instance, IoT applications are mounted for observing besides administration of energy, thereby upgrading varied access to power consumption and accordingly optimizing it [18, 19]. While considering the health segment, IoT is involved in observing of cold chain for vaccines, which needs implementation [20]. Water conservation stands as other segment which has immense prospects for IoT implementation, which focusses on endowment of water in terms of sanitary plus agriculture, and they are being developed and implemented in countryside zones of emerging republics [20]. IoT has implementation of disaster management situations in developing republics to handle natural catastrophes [21] like sensing tremors, surge in tidal wave. For the emerging republic, constraint in terms of resources leads to more economical solutions, which are operative in an emerging republic framework. Table 16.1 discourses some of the valuable research findings which are quite critical part of the literature review.

Sustainable growth planning necessitates settlement besides balancing association amongst atmosphere, budget, plus humanity, which is showcased in Fig. 16.1.

The three purposes of sustainability are associated amongst themselves. For accomplishing the optimum resolution, these three verticals are considered altogether [22].

16.3 Criteria in Energy Planning for Sustainable Development

Various procedures in three spheres of sustainability observes the presentation and impact while considering growth in terms of energy reserve. Each process is taken into account while keeping the energy reserve choice in mind. Righteous procedures will continuously formulate as an important feature in terms of energy resource, besides will remain as constant choice of selection [23]. Authors in [24] designated comparable four main methods of sustainable development in energy expansion, which including monetary, administrative and recyclable usages. Capability, asset price, process and upkeep cost, CO_2 emanation, are amid inspirations, being a part of energy planning process. The primary purpose of evaluating dissimilar substitutions comprising in terms of selection of an expansion track considering an energy sector contributing to sustainable growth of a nation. Sustainable expansion aspects were acknowledged because of matters catastrophe in energy segment of any republic or nation, counting the economic vertical (investment needs plus lack of local energy sources supplemented by a high prospective for green energy fabrication), social (price directive besides necessities about energy security), and conservational or ecological (environmental sustainability), as well as technical (innovation in terms of energy system). The evaluation criteria for sustainable energy planning is being discussed in Table 16.2.

Table 16.1 Summary of literature review

Authors	Title	Findings
Drexhage, J., & Murphy, D. [11]	Sustainable development: from Brundtland to Rio 2012	It labeled the perception of requirements and restraints in terms of sustainability
Kantartzis, A., & Pollalis, S [12]	Sustainable Green Infrastructure Planning in Greece: Proposal for an Urban Greenway Network in the Greater Athens Metropolitan Area	Clarified the perception of societal apart from monetary benefits of adapting to sustainable development
Frappaolo, V [13]	Benefitting from Sustainable Development	Elucidated the discernment of societal apart from monetary benefits of adapting to sustainable development in terms of energy
Hák, T., Janoušková, S., & Moldan [14]	Sustainable Development Goals: A need for relevant indicators	Deliberated regarding three domains of sustainability
Robert, K. W., Parris, T. M., & Leiserowitz, A. A [15]	What is sustainable development? Goals, indicators, values, and practice.	Discussed global development exploration epicenter allowing social needs and resource management
Rahim, A. [16]	IoT and data analytics for developing countries from research to business transformation	Discussed IoT in collaboration with resource management
Barro, P. A., Degila, J., Zennaro, M., & Wamba, S. F. [17]	Towards smart and sustainable future cities based on Internet of things for developing countries	Conversed IoT in association with resource conservation
Garrity, J [18]	Harnessing the Internet of Things for global development	Discussed regarding energy optimization in case of energy management
Ramanathan, T., Ramanathan, N., Mohanty, J., Rehman, I. H., Graham, E. [19]	Wireless sensors linked to climate financing for globally affordable clean cooking. Nature Climate Change	Conferred regarding energy optimization in case of energy controlling
Bloom, D. E., Black, S., Salisbury, D., & Rappuoli, R [20]	Antimicrobial resistance and the role of Vaccines. Proceedings of the National Academy of Sciences	Deliberated regarding water conservation with respect to IoT device management
Zorn, M [21]	Natural disasters and less developed countries. In Nature, tourism and ethnicity as drivers of (de) marginalization	Deliberated regarding sanitary and agricultural concepts with respect to IoT operation

Energy stands as the critical and prime factor while considering varied prospects in terms of sustainable development. The rudimentary magnitudes of sustainability in case of energy production are ecologically, theoretically, economically and publically sustainable sources of energy resources which is quite dependable, tolerable besides reasonable in long term usage. Renewable, uncontaminated and cost operative sources of energy are always favored however regrettably none of the unconventional sources of energy are good enough in terms of meeting these loads

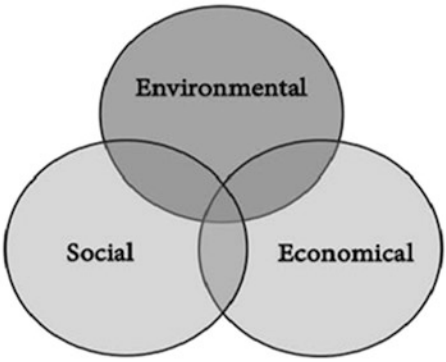

Fig. 16.1 Sustainability spheres. [22]

Table 16.2 Evaluation criteria for sustainable energy planning

Pointer	Norms
Technical	Energy fabrication capability
	Technological development
	Consistency
	Safety
Economical	Outlay cost
	Operation and maintenance cost
	Service life
	Reimbursement epoch
Environmental	Influence on ecology
	CO_2 emanation
Social	Communal assistances
	Societal adequacy

exclusively. Therefore, while determining the sustainable energy planning any tool which is strategic in nature can be considered for the overall development.

16.4 "Internet of Energy" Technology for Energy Management

Energy managing organization comprises relentless watching of oil distribution system, engendering elements, besides broadcast in addition to dissemination arrangements. Therefore, it means that significant data is accessible to sub divisions except the operation department. Information Technology protected Energy Administration and Controller System (EACS), which signifies a withdrawal from strategies factually, accompanying with energy administration systems. IT helps in integrating in terms of forecasting, observing and regulating power

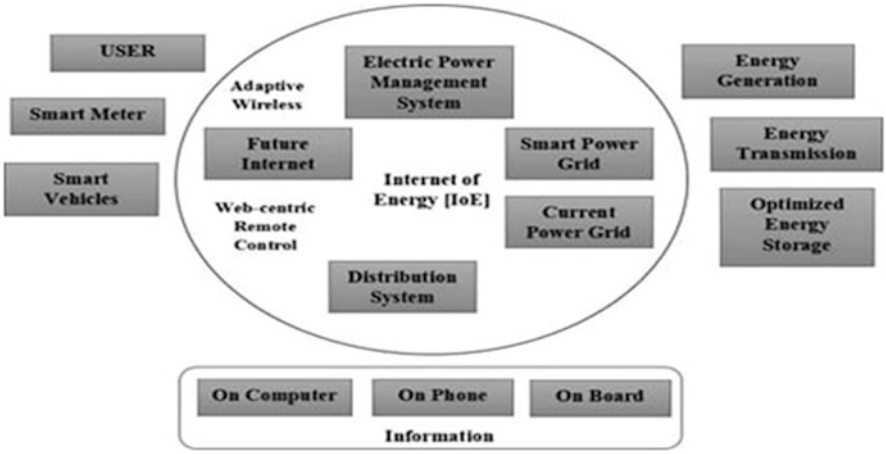

Fig. 16.2 Internet of energy architecture [25]

procedure and administration considering energy allotment amongst additional and dearth sections. The architecture of Internet of Energy is being showcased in Fig. 16.2. Management of energy in reducing functioning charge, minimalizing conservational impression besides upsurge in effectiveness is the prime goal. Since energy never noticed as "core" constituent of commercial commotion, a random tactic is charted. As and when the energy is supplied in small amount or in cases if energy charges increase, energy management turn out to be a chief emphasis. Operative managing of energy necessitates an administrative construction that uplifts the prominence of energy within the commercial sphere and defines the individuals, resources and planning to realize the anticipated output [25]. A business should have propagated an idea for effectively addressing any challenges. At times, plans must encounter constitutional requests and obey procedures very strictly, for instance like wellbeing plus safety, conservational administration. Considering such concerns, and cumulative levelling up of legislation and energy utilization, broadcasting techniques and the necessity of business competence ensures that facilities administrators must recognize that energy management requires comparable levels of possession plus accountability all over the association i.e., from top to bottom. In totaling, peoples should comprehend their role-play in decreasing pointless energy usage. The approach besides idea must need full sustenance at the official and operative level. The purpose must guarantee the approach is entrenched in the administrative policies and transforms the overall business as a whole. As the overall energy administration systems matures, besides developments, which will be focusing on the best solution for optimizing of energy completely [26]. Energy management is directly associated with scheduling, observing, besides regulating energy-associated progressions keeping in view the ultimate aim to reserve energy resources besides considering the factor of cost also in order of guarding the atmosphere. The applications of energy management approaches on varied systems, necessitates

massive cost in the beginning, though by energy management it saves a lot of cost later. Though the annexation of numerous novel devices besides varied arrangements in terms of energy management declines the comprehensive constancy of systems. A major chunk of energy management system is very much recyclable, but considering the fact that they can be applied to a certain extent only. The equilibrium in between the energy ingestion besides generation should be taken care off to avoid any sort of disorder. Energy administration approaches necessitates enormous extent of energy storage systems for appropriate operational functioning, though their restricted capabilities make it quite problematic in efficient application in terms of energy administration approaches. Some of the smart energy management solutions are deliberated below [27]:

Smart Buildings: It involves the designing of buildings or structures energy wise and facilitating in terms of optimizing energy use besides facility administration. Connectivity in terms of heating, ventilating, besides air conditioning systems which is under strict monitoring and control, results in substantial energy saving. Smart Building can use JouleX design in terms of enabling IT departments to power-off devices in addition to computers distantly at any particular point of time as this software has the ability in waking up devices for upkeep work or turn off complete systems for the period of holiday or vacation. IP-centered physical access controls allows door access systems in receiving their power via Ethernet with the help of network switches and it lessens the cabling besides energy costs.

Smart Grids: It involves physical plant's generation besides dissemination of energy in addition to other substructures. A well-executed established smart grid may result in annual gain of 3–6% in in terms of grid efficiency.

Smart Meters: A foremost constituent of smart grids is Smart Meters as they help in identification of inadequacies besides reducing waste.

Any organization should be in close proximity with its customers with the help of varied system competences in order to attain a sustainable and modest IoT centered smart systems especially critical for companies facing monetary, environmental, and societal challenges [28]. In rapid product development lifecycles addressing to all budding digital technologies like big data analytics, smart mobile device, the IoT-centered smart systems have become extremely critical for enterprises and ultimately catering to the need of organizational sustainability. IoT-enabled smart system includes an integrated architecture of varied hardware and software constituents [29]. IoT involves variable ranks of communication networking substructure in terms of providing collaboration amongst gears besides persons to form a congregated space [30]. IoT-centered smart systems comprises of embedded hardware besides software components, subsystems and IoT empowers the comprehension of numerous devices for individual, corporate applications [31]. These systems also support in assortment besides distribution of user thoughts and understandings of varied services. Consequently, an IoT-centered smart system is authorized in terms of interaction amongst network constituents and services [32].

16.5 Challenges in Energy Management for Sustainability

Energy Management is important in minimizing energy costs in the industry, improving business performance and enabling the realization of energy/CO_2 reduction objectives [33]. The ISO 50001 – Energy Management offers an infrastructure for power management systems with the worldwide prototype of plan, do, check, act' which is often modified to accomplish enhancements in the world of engineering. Power consumption information is very important, but meters below costly prices are often not in the right place as the operating time and power consumption profile are not clear. How power management is commenced, and the responsibilities associated with roles can vary depending on the type of organization and the lifespan of the installation [34]. For energy to be successful, success must be a process- driven by a process of change that is based on technology that carefully evaluates how, where, why, and how energy is utilized. Vigilant monitoring and evaluation will recognize areas and chances for enhancement [35, 36]. Thereafter it is tough to understand and rectify data error in a place where the product will not be interrupted [37]. The issues of collecting and managing data are presented by the design of production models and machine outlines that form an idea of factory activities based on accessible data. A 2-D image of factory line processes making use of machine profiles with real data from sub-meters as an authentication of the finalized process model used as a warning of the rise of malfunctions [38]. As the cost of energy increases, concerns about the provision of durable energy and legal responsibilities for productions and climate transformation, there are many challenges related to energy management. The performance of energy management depends on the organization type and the installation process: large areas will possess duty holder with a definite part; some employers in small corporations take the role as more than one job among countless. The energy manager may turn off the lights where necessary, but the engineering manager needs the lights on for keeping the production process going. The facility executive wants a well-managed environment for all inhabitants to promote and provision production. There is a conflict of interest, but all processes require to be carried out together. Therefore, Ownership is the major issue, as who is responsible for Energy Management Problem? An organization must have a strategy to deal with the problem effectively. Legal responsibilities on health and safety, environmental management and chances are generated as per company procedures. Energy management requires the same level of proprietorship and accountability from higher to lower level [39]. Employees and visitor's requirement to comprehend their role in minimizing needless energy consumption. Effective energy management can be considered as process-based system that carefully evaluates where, what, why and how energy is consumed. Cautious investigation recognizes opportunities for development. A structure for energy management system utilizes the standard model of "Plan, Do, Check, Act", which is frequently improved to accomplish enhancements in the engineering area. However, no resolution is available: energy management systems must have suitable approaches and policies for using different types of equipment. A strategic direction is essential and

agreements must be made on the processes that will utilize the resources efficiently keeping in mind the blend of technology and ecology [40].

16.6 Conclusion and Future Scope

Optimization of energy management and consumption is essential for ideal utilization of energy resources to fulfil the expectations of human society. Usually, the aim of an energy management system is to obtain, utilize, and produce energy in effective way. The energy sector and its amalgamation with information technology will pose important challenges and opportunities for industries and people in upcoming years. Previously, the electric power industry has never faced as significant challenges as it has in the past period of this era. Such challenges put straight influence on the process and control of electrical systems. Emerging technologies associated to microprocessors, communications, and computer that provide opportunities to embrace the issue. Rising energy utilization and many obstacles in its extraction, now facing many nations, have led scholars and customers, including businesses, industry and domestic segments, to explore novel and appropriate resolutions to upsurge production and reducing destructive impacts of consumptions. Amongst issues are resource depletion and renewable energy trends, environmental variations, and trends in the information systems network, rising electricity prices and technological advances. The outcome of the chapter demonstrates that IoE is able to detect heat, light, noise, heat and humidity in the environment, manage energy in smart environment, reduce carbon emissions, and protect from environmental indemnities. The analysis illustrates that the aim of sustainability is achievable only by facing major changes in the current power infrastructure. Recognizing renewable energy and seizing opportunities and managing energy establishes a renewable energy market and slowly builds a professional experience. The requirement to move into the future of sustainable energy through the widespread use of renewable energy will be a major challenge in Energy management. The utilization of the Internet for energy technologies applies to a variety of situations including the following, which can be considered a future course of study in terms of sustainable growth for any developing nation:

- Acknowledgement of Energy Sources.
- Alternate conducts of substituting renewable Energy Resources.
- Execution of Smart Energy Management System.
- Model Demonstration for the execution of Internet of Energy.
- Thoughtful structure of Internet of Things.
- Utilization of wireless sensor networks in Industry.
- Efficient utilization of energy-exhaustive materials.
- Augmented usage of renewable sources of energy.
- Well-organized manufacturing and usage of fuels.
- Replacement from high to low carbon or no carbon-based fuels.

Considering the above factors in case scenario of metropolitan and rural energy management system would be very useful as well as quite fruitful in achieving sustainable energy standard. As metropolitan and rural planning and development involves the efficient and orderly regulation of all activities, which would be quite helpful in the improvement of metropolitan and rural social, economic and environmental benefits keeping the ultimate aim of achieving sustainability in all aspects. Therefore, future work would involve attainment of optimization in terms of energy usage in a metropolitan as well as rural scenario keeping the economic growth also in consideration.

References

1. Roy, J., Chatterjee, B., & Basak, S. (2008). Towards a composite sustainability index: How are the states and union territories of India doing? *Indian Economic Review, 5*, 54–76.
2. Roy, J. (2014, March). Challenges and opportunities of sustainable low carbon green growth strategies for mega cities: A case study of Kolkata. In *2014 international conference and utility exhibition on green energy for sustainable development (ICUE)* (pp. 1–5). IEEE.
3. Grin, J., Rotmans, J., & Schot, J. (2010). *Transitions to sustainable development: New directions in the study of long-term transformative change*. Routledge.
4. Ritchie, H., & Roser, M. (2018). *Urbanization. Our world in data*.
5. Qiang, C. Z., Kuek, S. C., Dymond, A., & Esselaar, S. (2012). *Mobile applications for agriculture and rural development*.
6. Serban, O. (2015). Sustainable rural development in the knowledge age. *Quality-Access to Success, 16*.
7. Reese, H., Routray, P., Torondel, B., Sclar, G., Delea, M. G., Sinharoy, S. S., & Clasen, T. (2017). Design and rationale of a matched cohort study to assess the effectiveness of a combined household-level piped water and sanitation intervention in rural Odisha, India. *BMJ Open, 7*(3), e012719.
8. Van Dijk, H., Onguene, N. A., & Kuyper, T. W. (2003). Knowledge and utilization of edible mushrooms by local populations of the rain forest of South Cameroon. *Ambio: A Journal of the Human Environment, 32*(1), 19–23.
9. Chandramouli, C., & General, R. (2018). *Census of India 2011. Provisional population totals*. Government of India.
10. Sharma, A. (2007). The changing agricultural demography of India: Evidence from a rural youth perception survey. *International Journal of Rural Management, 3*(1), 27–41.
11. Drexhage, J., & Murphy, D. (2010). *Sustainable development: From Brundtland to Rio 2012* (pp. 9–13). United Nations Headquarters.
12. Kantartzis, A., & Pollalis, S. (2019). Sustainable green infrastructure planning in Greece: Proposal for an urban greenway network in the Greater Athens Metropolitan Area. In *Proceedings of the Fábos conference on landscape and greenway planning* (Vol. 6, No. 1, p. 45).
13. Frappaolo, V. (2017). Benefitting from sustainable development. *Sustainable Development Law & Policy, 17*(2), 6.
14. Hák, T., Janoušková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators, 60*, 565–573.
15. Robert, K. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is sustainable development? Goals, indicators, values, and practice. *Environment: Science and Policy for Sustainable Development, 47*(3), 8–21.

16. Rahim, A. (2017, September). IoT and data analytics for developing countries from research to business transformation. In *International conference on the economics of grids, clouds, systems, and services* (pp. 281–284). Springer.
17. Barro, P. A., Degila, J., Zennaro, M., & Wamba, S. F. (2018). Towards smart and sustainable future cities based on Internet of things for developing countries: What approach for Africa? *EAI Endorsed Transactions on Internet of Things, 4*(13).
18. Garrity, J. (2015). *Harnessing the Internet of Things for global development*. Available at SSRN 2588129.
19. Ramanathan, T., Ramanathan, N., Mohanty, J., Rehman, I. H., Graham, E., & Ramanathan, V. (2017). Wireless sensors linked to climate financing for globally affordable clean cooking. *Nature Climate Change, 7*(1), 44–47.
20. Bloom, D. E., Black, S., Salisbury, D., & Rappuoli, R. (2018). Antimicrobial resistance and the role of vaccines. *Proceedings of the National Academy of Sciences, 115*(51), 12868–12871.
21. Zorn, M. (2018). Natural disasters and less developed countries. In *Nature, tourism and ethnicity as drivers of (de) marginalization* (pp. 59–78). Springer.
22. Dagnaw, G. A., & Tsige, S. E. (2019). Impact of Internet of Thing in developing country: Systematic review. *Internet of Things and Cloud Computing, 7*(3), 65.
23. Wang, J. J., Jing, Y. Y., Zhang, C. F., & Zhao, J. H. (2009). Review on multi-criteria decision analysis aid in sustainable energy decision- making. *Renewable and Sustainable Energy Reviews, 13*(9), 2263–2278.
24. Mohamed, M. A. (2019). *A multicriteria decision aid approach for energy planning problems: The case of renewable energy option in Somalia*. Doctoral dissertation.
25. Mohammadian, H. D. (2019, April). IoE–A solution for energy management challenges. In *2019 IEEE global engineering education conference (EDUCON)* (pp. 1455–1461). IEEE.
26. Miglani, A., Kumar, N., Chamola, V., & Zeadally, S. (2020). Blockchain for Internet of Energy management: Review, solutions, and challenges. *Computer Communications, 151*, 395–418.
27. Shafik, W., Matinkhah, S. M., & Ghasemzadeh, M. (2020). Internet of things-based energy management, challenges, and solutions in smart cities. *Journal of Communications Technology, Electronics and Computer Science, 27*, 1–11.
28. Belli, L., Cilfone, A., Davoli, L., Ferrari, G., Adorni, P., Di Nocera, F., ... & Bertolotti, E. (2020). IoT-enabled smart sustainable cities: challenges and approaches. *Smart Cities, 3*(3), 1039–1071.
29. Abduljabbar, R. L., Liyanage, S., & Dia, H. (2021). The role of micro-mobility in shaping sustainable cities: A systematic literature review. *Transportation Research Part D: Transport and Environment, 92,* 102734.
30. Giles-Corti, B., Moudon, A. V., Lowe, M., Adlakha, D., Cerin, E., Boeing, G., ... & Sallis, J. F. (2022). Creating healthy and sustainable cities: what gets measured, gets done. *The Lancet Global Health, 10*(6), e782–e785.
31. Allam, Z., & Jones, D. S. (2021). Future (post-COVID) digital, smart and sustainable cities in the wake of 6G: Digital twins, immersive realities and new urban economies. *Land Use Policy*, *101*, 105201.
32. Bibri, S. E., & Krogstie, J. (2020). Environmentally data-driven smart sustainable cities: Applied innovative solutions for energy efficiency, pollution reduction, and urban metabolism. *Energy Informatics, 3*(1), 1–59.
33. Kumari, A., Gupta, R., Tanwar, S., & Kumar, N. (2020). Blockchain and AI amalgamation for energy cloud management: Challenges, solutions, and future directions. *Journal of Parallel and Distributed Computing, 143*, 148–166.
34. Alam, M. S., & Arefifar, S. A. (2019). Energy management in power distribution systems: Review, classification, limitations and challenges. *IEEE Access, 7*, 92979–93001.
35. Gupta, S., & Vyas, S. (2021). IoT in green engineering transformation for smart cities. *Smart IoT for Research and Industry, 121*.
36. Arora, A., Kaur, A., Bhushan, B., & Saini, H. (2019, July). Security concerns and future trends of internet of things. In *2019 2nd international conference on intelligent computing, instrumentation and control technologies (ICICICT)* (Vol. 1, pp. 891–896). IEEE.

37. Bhushan, B., Sahoo, C., Sinha, P., & Khamparia, A. (2021). Unification of Blockchain and Internet of Things (BIoT): Requirements, working model, challenges and future directions. *Wireless Networks, 27*(1), 55–90.
38. Sethi, R., Bhushan, B., Sharma, N., Kumar, R., & Kaushik, I. (2021). Applicability of industrial IoT in diversified sectors: Evolution, applications and challenges. In *Multimedia technologies in the Internet of Things environment* (pp. 45–67). Springer.
39. Varshney, T., Sharma, N., Kaushik, I., & Bhushan, B. (2019, October). Architectural model of security threats & their countermeasures in IoT. In *2019 International conference on computing, communication, and intelligent systems (ICCCIS)* (pp. 424–429). IEEE.
40. Saxena, S., Bhushan, B., & Ahad, M. A. (2021). Blockchain based solutions to secure IoT: Background, integration trends and a way forward. *Journal of Network and Computer Applications, 181*, 103050.