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Technology Executive Committee

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Draft compilation of good practices and lessons learned from the setup and implementation of national systems of innovation

Cover note

I. Background

1. As per activity 1 of the thematic area Innovation of its updated workplan for 2019–2022,[1] the Technology Executive Committee (TEC) is to explore the setup of national systems of innovation in different countries and regions and analyse ways to incentivize innovation of mitigation and adaptation technologies.

2. The final outputs of this activities are:

(a) A compilation of good practices and lessons learned from the setup and implementation of national system of innovation (NSI);

(b) Recommendations on how to incentivize innovation and/or an update of the TEC brief on NSI.[2]

3. At TEC 24, the TEC provided guidance on the development of the compilation, on developing the compilation, emphasizing the importance of building on previous work of the TEC on NSIs, as well as on incubators and accelerators. The TEC also underlined the importance of elaborating national and international linkages between the various actors involved in NSIs, including the role of the private sector and education institutions in supporting national innovation efforts, as well as the contribution of NSIs to NDC implementation.

4. TEC 24 also agreed that any consideration of increasing the number of case studies to be analysed for the compilation will be made at TEC 25.

5. The task force on Innovation worked inter-sessionally, with the support of the secretariat and a consultant, to prepare a first draft of the compilation analysing three case studies.

II. Scope of the note

6. The annex to this note contains the draft compilation of good practices and lessons learned from the setup and implementation of NSI.

III. Expected action by the Technology Executive Committee

7. The TEC will be invited to consider the draft compilation and provide guidance to the innovation task force for further work on the compilation, including on increasing the number of case studies to be analysed.

[1] See https://bit.ly/3M0nyRp.

[2] See https://bit.ly/3siS55h.

Annex

Draft compilation of good practices and lessons learned from the setup and implementation of national systems of innovation

Contents

Foreword

[*Foreword by the TEC Chair and Vice-chair to be added at later stage*]

Highlights

Article 10, paragraph 5 of the Paris Agreement states that accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. Countries' capabilities to drive and enable climate technology innovation are crucial in this regard. These capabilities are determined in part by the effectiveness of countries' national system of innovation (NSI). The recognition of good practices, even though implemented in specific country/sectoral contexts, can provide useful insights to support other countries in developing or strengthening such systems.

The primary aim of this compilation is to share lessons learned and good practices on the setting up and implementation of NSIs for the use of developing country policymakers looking to strengthen their NSI in the context of climate action. It aims to deepen the understanding of NSIs (or parts thereof) and identify measures and approaches which have improved the effectiveness of the national systems in specific cases and translate them into good practices that can be replicated in other countries.

To this aim, a number of case studies has been selected taking into account the maturity and availability of information of the initiative, a balance between mitigation and adaptation technologies, sectors and geographic regions and income levels of the countries,. The case studies included in the current version of the compilation include the Indian Bureau of Energy Efficiency, the Kenya Climate Innovation Center and Haiti's Disaster Risk Reduction strategy.

Within the scope of this compilation it is not possible to evaluate entire national innovation systems, given their size and complexity. The assessment looks at selected parts of NSIs, focussing on functions and structural components of innovation systems.

Main lessons learned and success factors that may be relevant to other countries include:

1. A systemic perspective, integrated with host country development objectives;
2. A tailored approach to bridging sector- and innovation phase-specific gaps;
3. Participation of local actors and inclusion of local knowledge and coordination among actors;
4. Engage with international institutions and collaborations to help build local institutions, networks;
5. Ensure that innovation and organizations are evolutionary and able to adapt to new circumstances;
6. Pay attention to long-term planning and continuous monitoring and review.

Drawing from the analysis of the case studies, the overall recommendation is that implementation of the NSI is best guided through a systematic approach that draws upon NSI functions and structure-function frameworks as a way to suitably organize efforts. Specifically, the objective would be to help ensure that the NSI is organized and resourced suitably so as to perform the functions required for successful innovation. But since many of the details are sector-specific, it is recommended that the process begins with an identification of sectoral priorities aligned with national policy goals and socio-economic objectives. This can then guide and facilitate, as needed, the process of strengthening of NSI functions, marshalling of resources, and addressing weaknesses/gaps in structural elements in NSIs. Good practices for potential replication that have been identified in the various case studies lead to the following specific recommendations:

- Map the NSI before designing and implementing strategies;
- Look for win-win measures across the various stakeholders;
- Coordinate and integrate with long-term policy framework;
- Evolve and diversify through learning by doing;
- Learn iteratively and be adaptive to evolving situations and needs;
- Create complementary knowledge and servicing infrastructure;
- Allow flexibility in how policy goals are met;
- Establish a coordinating agency with clear roles and responsibilities;
- Use international collaborations to develop local capabilities and resources;
- Design innovative, customized, and flexible funding frameworks;
- Pay attention to market creation for climate technologies;
- Engage both public and private sectors;
- Integrate the goals of climate initiatives with local policy goals and socio-economic priorities;
- Focus beyond hardware innovation to include software and orgware (capacity building, communication, policies);
- Strengthen local capabilities, while ensuring coordination;
- Plan according to longer time frames, while allowing monitoring, evaluation and review.

Here it should be noted that the current version of the compilation is based on a limited number of case studies, which limits to some extent both the number of lessons learned and good practices and the extent to which lessons can be deemed generally applicable. After further case studies have been carried out, the above will be updated and elaborated to reflect additional insights.

1. Introduction

Article 10, paragraph 5 of the Paris Agreement states that accelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development. Countries' capabilities to drive and enable climate technology innovation are crucial in this regard. These capabilities are determined in part by the effectiveness of its national system of innovation (NSI).

The primary aim of this compilation is to share lessons learned and good practices on the setting up and implementation of NSIs for the use of developing country policymakers looking to strengthen their NSI in the context of climate action. It aims to deepen the understanding of NSIs (or parts thereof) and identify measures and approaches which have improved the effectiveness of the national systems in specific cases and translate them into good practices that can be replicated in other countries. The analysis aims to deepen the understanding of (parts of the) NSIs[1] and identify measures and approaches which have improved the effectiveness of the national systems. The recognition of good practices, even though implemented in specific country/sectoral contexts, can lead to cross-learning (exchange of knowledge and experience).

To this aim, a number of case studies has been selected across a range of countries, covering both mitigation and adaptation initiatives. For this version of the compilation, so far 3 case studies have been analysed in detail. The ultimate selection of case studies will take into account the need to cover both mitigation and adaptation initiatives and have an appropriate representation across regions and country income groups, as well as across sectors. The case studies will also cover different innovation system perspectives (national/sector/ technology-focused). NSIs need to be sufficiently mature to facilitate meaningful evaluation, have a potential for providing good practices and/or useful lessons learned and sufficient availability of information.

The next section introduces the concepts and approach used in this report. Table 1 provides an overview of the case studies selected. The first three are discussed in section 3 of this version of the compilation.

Section 4 summarizes the lessons learned and identified good practices across case studies, on which basis Section 5 presents some key recommendations for enhancing NSIs.

Table 1 Overview of the selected case studies

Case study	Country - region	Mitigation/ adaptation	Sector	Type of country/ income level	Top-down/ bottom-up	Main IS functions	Comment
1st version (August)							
BEE Bureau of Energy efficiency	India – Asia	Mitigation	Energy efficiency – economy wide	Lower Middle Income	Top-down	F1 Knowledge development & diffusion F2 Entrepreneurial experimentation F3 Market formation	
KCIC Kenya Climate Innovation Center	Kenya – Africa	Mitigation + adaptation	Energy (RE + EE), agriculture, water, waste, forestry	Lower Middle Income	Top-down	F1 Knowledge development & diffusion F2 Entrepreneurial experimentation F3 Market formation F5 Resource mobilization	
Disaster Risk Reduction	Haiti - Caribbean	Adaptation	All sectors	Low-Income	Top-down & bottom-up	F1 Knowledge development & diffusion F4 Guidance of search F5 Resource mobilization F6 Legitimation	
In 2nd version (after TEC Sept)							

[1] Within the current scope it is not possible to evaluate entire national innovation systems, given their size and complexity. Therefore, the assessment looks at selected parts of NSIs.

Bio-ethanol programme	Brazil – Latin America	Mitigation	Transport (Energy/ Agriculture)	Upper Middle Income			Or broader bio-energy (also charcoal in steel)?
In extended version (6 cases) – To be decided at TEC 25							
?		Mitigation	Energy supply				
?		Adaptation	Water management?				

2. Concepts and approach

2.1. Definitions and concepts – Innovation and Innovation Systems

2.1.1. Innovation

'Innovation' has been defined in a myriad of ways, but the idea of 'newness' is central to most interpretations[2]. In short, innovations 'are new creations of economic significance' and could be either completely new (radical) or an amalgamation or improvization (incremental) of the existing elements[3]. Innovation is both the process and the outcome of creating something new that adds value to the broader domains of economy and technology.

Innovations can relate to processes or products. Process innovations include organizational and technological changes, while product innovations include changes in materials, goods or services. Innovation relates not only to new-to-the world products and knowledge. When a product is first used in a certain context, this can also be an innovation.

The recent IPCC Sixth Assessment Report on Mitigation for the first time contained a chapter on innovation.[4] It emphasises that innovations occur in dynamic processes emerging from interactions between different actors and between R&D, economic application, and further improvization through learning by doing and learning by using. Actors engaged in the development and diffusion of technologies interact via networks, and the interactions are regulated by institutions which include formal rules, such as laws, and informal restraints, such as culture and codes of conduct. Furthermore, the innovation process is systemic and inherently non-linear due to interactions between science, technology, policy, economics, learning, etc. There are several feedback loops in technological development, for instance, between knowledge generation, knowledge translation and application, and knowledge use. This implies that innovations do not come only from R&D, but also from production engineers and the shop floor, for example. This explains the high levels of path-dependence and inertia that impedes innovation, including introducing cleaner technologies, processes, and organizations. The systemic nature of innovation assessed in the IPCC chapter on innovation is taken as a basis for this compilation. While there has been much effort and positive results in innovation for climate technology over the past years, the IPCC also notes that innovation does not come without trade-offs, such as negative externalities and rebound effects.

The TEC has been analyzing and highlighting the significance of innovation in achieving the purpose of the climate and Sustainable Development Goals. The latest TEC Brief on Innovative approaches to accelerating and scaling up implementation of mature climate technologies[5] notes that effective implementation of technologies for climate mitigation and adaptation calls for not only technical innovations but also innovations in the way actions are planned, actors collaborate, and funding is sourced. These innovations facilitate government action to 'push' and market forces to 'pull' these technologies for wider implementation. Earlier work by the TEC on energizing entrepreneurs to tackle climate change also explicitly acknowledges the importance of entrepreneurs in developing technologies, business models and services for low-emission and climate-resilient sustainable development[6].

[2] Johannessen, J. A., Olsen, B., & Lumpkin, G. T. (2001). Innovation as newness: what is new, how new, and new to whom?. *European Journal of innovation management*.

[3] Edquist, C. (1997). Systems of innovation approaches–their emergence and characteristics. Systems of innovation: Technologies, institutions and organizations, 1989, 1-35.

[4] Blanco, G., H. de Coninck, L. Agbemabiese, E. H. Mbaye Diagne, L. Diaz Anadon, Y. S. Lim, W.A. Pengue, A.D. Sagar, T. Sugiyama, K. Tanaka, E. Verdolini, J. Witajewski-Baltvilks, 2022: Innovation, technology development and transfer. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.018

[5] TEC Brief 14, 2021 Brief, Innovative approaches to accelerating and scaling up implementation of mature climate technologies. https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/brief14/c4e1c145de494f2ea43c37dfd742f9e5/06260bdc8782406ab442084dc64ccf94.pdf

[6] TEC, 20, TEC Brief #12 Energizing Entrepreneurs to Tackle Climate Change, UNFCCC Technology Executive Committee, Bonn, https://unfccc.int/ttclear/tec/brief12.html

2.1.2. Systems of Innovation

The idea of Systems of Innovation (SI) is an established conceptual framework for studying innovation processes while taking into account their systemic nature, and can generate insights for policmakers[7]. "The elements and relationships which interact in the production, diffusion, and use of new, and economically useful, knowledge" comprise a system of innovation[8]. An innovation system is made of 'components, relationships, and attributes'[9]:

- **Components** are the 'operating parts' (actors, organizations, and institutions);
- **Relationships** are the market and non-market inter-linkages between the components (feedback mechanisms; technology spill-overs, transfer, acquisition, etc.); and
- **Attributes** are the properties and capabilities of the components which characterize the system (system's 'robustness, flexibility, ability to generate change and respond to changes).

TEC Brief #7 on strengthening NSIs defines an NSI as "a network of actors, institutional contexts and linkages that underlie national technological change, existing of:

- **Actors**: Organizations that participate in technology development and transfer, e.g. technology firms, universities and financiers;
- **Institutional context**: Norms, cultural practices and laws that shape actor efforts, e.g. government policies that affect how the private sector invests in a particular sector;
- **Linkages**: Interactions and relations between the actors and the institutional context, e.g. flows of information and knowledge, and collaboration between firms, universities and research institutes".[10]

The concept of SI has been defined and understood at different complementary analytical levels, such as the national systems of innovation (NSI), regional systems of innovation (RSI), sectoral systems of innovation (SSI), and technological innovation system (TIS). These systems are conceptualised as fulfilling "functions" for technology development and also technology transfer. As such functions are often weaker in developing countries, the link between systems of innovation and the technology development and transfer discussions in the UNFCCC and its Paris Agreement are eminent.[11] Deliberations on regulatory frameworks and research priorities at the international level impact the systems of innovations operating at the national, regional, and sub-national levels. The systems boundaries between TIS, SSI, NSI, and the global innovation systems (GIS) are artificial and set up by researchers according to the case study in question[12]. In practice, systems are interconnected (Figure 1).

This means that when looking at an initiative aiming to foster innovation for climate action at the national level, this may overlap with different technologies and sectors. Importantly, actors, institutions, technologies and interactions may come also from the international level, and interact with those in the national level.

[7] Blanco et al., 2022

[8] Lundvall, B. Å. (2016). National systems of innovation: towards a theory of innovation and interactive learning. *The Learning Economy and the Economics of Hope*, *85*.

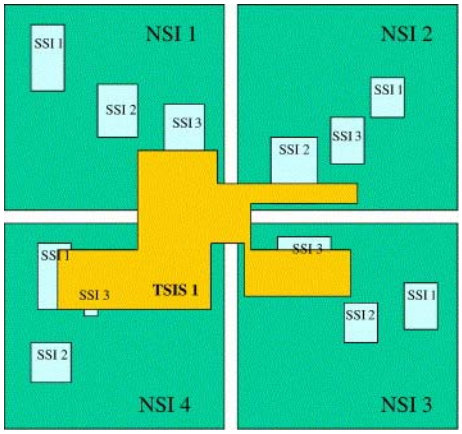
[9] Carlsson et al., 2002

[10] TEC, 2015, TEC Brief #7, Strengthening National Systems of Innovation to Enhance Action on Climate Change, UNFCCC Technology Executive Commission, Bonn, https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_documents/5be1bf880cc34d52a4315206d54a711b/60d1580f741a4bc783da5a00cf64a879.pdf

[11] Blanco et al., 2022

[12] Binz, C., & Truffer, B. (2017). Global Innovation Systems—A conceptual framework for innovation dynamics in transnational contexts. Research policy, 46(7), 1284-1298.

Figure 1 ***Boundary relations between National, Sectoral, and Technology Specific Innovation Systems***[13]



2.1.3. National Systems of Innovation and international linkages for climate action

As outlined in TEC Brief #7, NSI plays a central role in determining the effectiveness of a country's climate action and its initiatives to address developmental challenges. A country's capabilities to implement technological change is shaped by the strength of its NSI and its linkages with international innovation activities and systems. The pace and cost of climate action critically depend on innovations dealing with cleaner technologies [14].

The interconnections and exchanges between the NSIs and the international context (the GIS) are particularly relevant in the context of climate change. For instance, most successful cases in the energy transition have involved international collaboration,[15] with clean energy technologies rarely being developed in a single country and then physically transferred to another. International actors and collaborations can play a far-reaching role in complementing, catalyzing, and accelerating national efforts on strengthening NSIs by drawing on wide-ranging global experiences and expertise.

Our analysis aims to cover innovation systems that are relevant for climate change mitigation and/or adaptation technologies, but this can also include more general (not climate-specific) technology innovation systems. The analysis can have a national, sectoral or technology focus. Linkages of the national component to international actors and processes will be taken into account.

2.2. Approach to understanding NSI performance for climate action

This compilation aims to deepen the overall understanding of NSIs or elements of NSIs (initiatives by actors situated within the NSI) and thereby identify strategies, actions, or factors that can effectively contribute to national climate and development goals, explicitly the development and transfer of climate technologies. Although implemented under specific local and global contexts, the successful strategies or structures can form a basis for cross-learnings between regions and sectors and can lead to improvements in systems elsewhere. From the policy perspective, an enhanced understanding of the national systems can help recognize the 'leverage points' for strengthening the country's innovative performance and its overall competitiveness.

In general, innovation outcomes will depend on the overall functioning of the innovation system. There are different approaches for assessing the performance of innovation systems. This can range from the use of relatively simple **indicators**, to an analysis of existing **barriers** or based on the **functions** that a technology innovation system aims to perform. As discussed in TEC Brief #7, the indicator approach aims to measure a country's effort spent to stimulate innovation, a barrier approach

[13] Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). Functions of innovation systems: A new approach for analysing technological change. Technological forecasting and social change, 74(4), 413-432.

[14] See e.g. IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24, doi:10.1017/9781009157940.001

[15] See e.g., Gallagher, K. S. (2014). The globalization of clean energy technology: Lessons from China. MIT press. and Li, D., Alkemade, F., Frenken, K., & Heimeriks, G. (2022). Catching up in clean energy technologies: a patent analysis. The Journal of Technology Transfer, 1-23.

focuses on what can hinder innovation from taking place, while a functional approach aims to assess the overall functioning of the innovation system, in terms of how well key processes are being carried out[16].

Performance indicators can include input indicators and/or output indicators. Examples of indicators include national R&D investments, the number of scientific publications or the number of patents generated. While these indicators are relatively simple to assess, they are also limited in the extent to which they can help understand and improve NSIs, as they focus on only small parts of what constitutes an effective innovation process.

A broader perspective looks at **barriers** for innovation, beyond the availability of R&D funding. Here, the performance of NSIs is defined in terms of whether (and to what extent) barriers or systemic failures have been identified and addressed and whether (and to what extent) the desired objectives of the system are accomplished. In simple terms, barriers are factors that impede the development, acquisition, and diffusion of technologies and innovations[17]. The UNFCCC Technology Needs Assessment (TNA) initiative strives to help countries identify their climate technology needs and priorities, analyze the bottlenecks to effective diffusion of the priority technologies, promote national development and build countries' innovation systems.

The findings of developing countries' TNAs show that barriers are not only technical in nature, but that that they hinder the overall evolution of the innovation system. Barriers to climate technology innovation, development and transfer can occur in the entire innovation system. Barriers are context specific, but lack of financial resources, the local regulatory environment or lack of human capital are examples of commonly identified barriers. Barriers go beyond what can be captured by traditional indicators such as funding for R&D and number of patents. In fact, they include also network failures, policy and regulatory barriers, awareness, and even cultural aspects. [18]

The barriers link to four types of **resources** for innovation that need to be mobilized and coordinated for successful innovation systems: **knowledge, market formation, financial and human resources, and legitimacy**[19]. These resources allow the innovation systems to perform a range of **functions** needed to achieve successful innovations.

An innovation system's 'overall **function'** is to 'produce, diffuse, and use' innovations[20]. However, in order to recognize and influence the factors which drive or impede those processes, it is crucial to identify and understand in more detail the specific activities the systems (should) undertake to achieve the intended goals. This is – for a TIS – referred to as the different 'functions' of the innovation system. Functions explain 'what happens' in an innovation system, the activities of the actors and/or organizations pursuing innovation, the role played by institutions in promoting or impeding innovations, and the impacts of the interactions between the various structural elements.

Table 2 lists the functions of a TIS distinguished in literature. Table 3 correlates the four types of resources to the innovation system's functions. Although the functions approach was initially developed for TISs, the concept of a functional approach is also widely used for other systems of innovation approaches. The various SI approaches have a 'shared understanding' of the basic functions[21].

Table 2 Functions of Systems of Innovation[22]

#	Function	Description
F1	Knowledge development & diffusion	Expansion and intensification of the knowledge base of the innovation system, dissemination of knowledge among actors in the system, creation of new combinations of knowledge
F2	Entrepreneurial experimentation	Designing of business models for emergent technologies and knowledge, practices of uncertainty reduction through experimentation with new technologies, applications, and strategies
F3	Market formation	Creation of a space or an arena in which goods and services can be exchanged between suppliers and buyers. Includes processes related to definition of demand and choices, positioning (pricing, segmentation) of products, regulation of standards, and the rules of exchange.

[16] Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research policy, 37(3), 407-429.
[17] Nygaard, I., & Hansen, U. E. (2015). Overcoming barriers to the transfer and diffusion of climate technologies. (2nd ed.) UNEP DTU Partnership. TNA Guidebook Series http://www.tech-action.org/Publications/TNAGuidebooks
[18] UNFCCC, 2020: Fourth synthesis of technology needs for non-Annex I parties. https://unfccc.int/documents/218506
[19] Binz, C. Truffer, B., and L. Coenen (2016). Path Creation as a Process of Resource Alignment and Anchoring: Industry Formation for On-Site Water Recycling in Beijing. *Econ. Geogr.*, **92**, 172–200, https://doi.org/10.1080/00130095.2015.1103177
[20] Edquist, C. (2001, June). The Systems of Innovation Approach and Innovation Policy: An account of the state of the art. In *DRUID conference, Aalborg* (pp. 12-15).
[21] Johnson, A. (2001, June). Functions in innovation system approaches. In Nelson and Winter Conference, Aalborg, Denmark (pp. 12-15).
[22] Adapted from Bergek et al., (2008)

#	Function	Description
F4	Influence on the direction of search	Processes that influence the direction of research of firms and other actors; that is, which technologies they explore, which problems or solutions they choose to invest in, where they channelize their resources from, etc.
F5	Resource mobilization	Processes by which the system acquires resources required for innovation. The resources could be financial, human resources (workforce and capabilities), complementary assets such as infrastructure, etc.
F6	Legitimation	Mechanisms by which an emergent technology, its developers, and the TIS in question attain regulative, normative, and cognitive legitimacy as viewed by the concerned stakeholders.
F7	Development of positive externalities	Creation of 'system-level utilities (or resources), such as pooled labour markets, complementary technologies, and specialized suppliers, which are available also to system actors that did not contribute to building them up

Table 3 How the four types of resources relate to the functions of innovation systems[23]

Dimension	Function in TIS	Description
Mobilization of resources		
Knowledge	*Knowledge development*	Activities contributing to create new technological knowledge and competencies. Knowledge creation can relate to different types of knowledge (e.g. scientific, technological, production, market, logistics and design knowledge) and there can be different sources of knowledge development (e.g., learning by searching, learning by doing).
	Knowledge diffusion	Activities promoting exchange of information among the actors in the innovation system (e.g. learning by interacting, and learning by using in networks).
Markets	*Market formation*	Activities that create protected spaces for the new technology, helping to establish new market segments. Examples are policies that lead to the creation of competitive advantage by favourable tax regimes or minimal consumption quotes.
Financial & human resources	*Resource mobilization*	Activities that mobilize human and financial resources to the innovation process. Examples are funds for long term R&D programs or to allow testing of new technologies in experiments.
Legitimacy	*Development of external economies*	External economies regard the degree to which other interests benefit from the new technology. One example is the creation of development benefits, such as jobs, business opportunities, increased energy access and reduced air pollution.
	Creation of legitimacy or counteracting resistance to change	Activities that embed a new technology in existing institutional structures or adapt the institutional environment to the needs of the technology – e.g., a change in regulations in the energy sector that will introduce the possibility for decentralized electricity generation. Activities that allow a new technology to become accepted by users, often despite opposition by incumbent interests. This also relates to development of external externalities. As more actors benefit from the new technology, "winning coalitions are created", which help sustain public and political support[24]
Coordination		
	Guidance of the search	Activities within the innovation system that contribute to expectation management and provide a direction to technological change, by positively affecting the visibility and clarity of specific wants among technology users. Often an interactive process of exchanging ideas between technology producers, technology users, and other actors. This helps to reduce uncertainties and overcome deadlocks when some actors do not take action until they are certain that complementary investments will be undertaken by other parties.

2.3. Our approach

Since innovations are dynamic processes, static descriptions of SI characteristics or **structural components** (actors, technologies, institutions, and networks) cannot fully explain the determinants and evolution of innovation systems[25]. A functional evaluation is necessary to identify and assess the innovation system's achievements, failures, and gaps or barriers. The extent to which these functions can be performed, depends on whether the structural components are present and of

[23] Based on Binz et al. (2016), Hekkert et al. (2007) and Bergek et al. (2008).
[24] See e.g., Meckling J, Kelsey N, Biber E, Zysman J. Winning coalitions for climate policy. Science. 2015 Sep 11;349(6253):1170-1. doi: 10.1126/science.aab1336
[25] Hekkert et al., (2007).

sufficient quality: a system's underachievement is directly related to absences or weaknesses in its structural components[26]. Functions cannot be influenced without changing the structural constituents of the system; they are interrelated.

Enhancing the understanding of the drivers and gaps in national systems (or initiatives situated within NSIs) in this compilation is therefore based on a 'structure-function analysis', as explained below. Table 4 illustrates how the functional analysis (FI to F7) of an innovation system mentioned above in light of its structural components reveals the system's strengths and deficiencies (or missing links).

Table 4: Structure-Function Analysis[27]

Structural component	Systemic problem (Weakness)	Type of problem (weakness) related to
Actor (for F1 to F7)	Absence of relevant actor/s	Presence/absence
	Absence or inadequate capabilities in the actor/s	Capability
Institutions (for F1 to F7)	Absence of required/relevant institutions	Presence/absence
	Absence or inadequate capabilities in institutions	Capability
Interactions (for F1 to F7)	Absence of interactions between relevant actors and organizations (due to distance, lack of trust, lack of capabilities, divergent goals, etc.)	Presence/absence
	Inadequate quality or intensity of interactions (too strong, too weak)	Quality or intensity
Technology (incl. physical artefacts, knowledge setups, financial infrastructure, etc.)(for F1 to F7)	Absence of technology, infrastructure	Presence/absence
	Inadequate quality of the infrastructure	Quality

The absence or deficiency of functions or lack of synergy between functions denote 'weaknesses', 'barriers', 'systemic failures', 'blocking mechanisms', etc., and pose challenges for innovation.

The following section describes how the above concepts have been applied to the analysis in this compilation.

2.4. Case study selection and analysis

The study undertakes an analysis of a selection of (parts of) innovation systems as case studies. The selection of case studies aims to highlight initiatives or systems which have successfully addressed (part of) the challenges to climate technology innovation, leading to a well-functioning system. Hence, an important criterion considered for selecting the case studies is the maturity and available information of the initiative. Moreover, the selection of case studies ensures a balance between mitigation and adaptation technologies and between sectors; it also ensures regional and income level representation, keeping in mind the importance of replicability of success factors and the representativeness of lessons learned. The underlying rationale for selecting the cases is to highlight good practices (across sectors, regions, and climate goals) that can strengthen the processes and activities of climate-relevant innovation systems, and can form a basis for cross-learning between sectors and regions.

For a comprehensive analysis of the selected case studies and recognition of good practices for knowledge sharing, the case studies cover the following broad steps:

- First, the delivery of the initiative's functions is assessed. Here it should be noted that not every innovation system or initiative can be expected to deliver on all the functions[28]. Initiatives (or systems) could focus specifically on particular stages (knowledge creation, absorption, and application) or actors of the overall innovation system.
- Second, an analysis of the contribution of the initiative in addressing the barriers to climate innovation or the missing links and strengthening of the core areas in the overall innovation system is made. Recognising that the design and implementation of the initiatives would suit national objectives the analysis will aim to pinpoint factors that made them successful that are based on the common principles for improving innovation systems at the country levels.

Recognising the role of the initiatives in strengthening aspects of the NSI to help address specific climate and development challenges of the country will allow conclusions and recommendations (cross-country learning) to be based **not only on the**

[26] Wieczorek, A. J., and Hekkert, M. P. (2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. Science and public policy, 39(1), 74-87.
[27] Wieczorek and Hekkert (2012).
[28] Although it can be supported or complemented by other initiatives or systems.

***outcomes* of the initiative or innovation system, but also on the design and effectiveness of the *processes* leading to those outcomes.** Therefore, in explicit terms, the analysis will look at how initiatives in the innovation system contributed to:

- Enhancing the capabilities of the relevant actors;
- Strengthening the institutional context in which the actors operate;
- Enhancing linkages between actors, and actors and the institutional settings; and
- Catalyzing changes for knowledge production and its wider implementation, in order to achieve co-evolving goals of climate mitigation and adaptation, and sustainable development.

Given the complexity and interlinked functioning of the innovation processes and activities, attributing the final outcomes exclusively to specific initiatives can be challenging. Nonetheless, the broader context in which the innovation was embedded and which led to the delivery of particular outcomes would aid in identifying good practices.

3. Case studies

3.1. CASE: India Bureau of Energy Efficiency

Country	India	**Focus**	Mitigation
Scope	Energy-use sector (demand-side energy management)	**Key innovation system functions**	F1 Knowledge development and diffusion F2 Entrepreneurial experimentation F3 Market formation
Approach	Top-down	**Starting year**	2002

3.1.1. Introduction of the initiative

This case study highlights and evaluates the role of India's Bureau of Energy Efficiency (BEE) in popularizing energy conservation and efficiency practices in the Indian economy and shaping the country's innovation landscape. BEE was set up in 2002 as a quasi-regulatory[29] and policy making body at the national level to spearhead the transformation of the Indian energy efficiency market through various regulatory and promotional policy instruments.

BEE plays a crucial role in developing and deploying policies and strategies with a thrust on self-regulation and market principles and enhancing public and corporate awareness about energy conservation measures and practices spanning across economic sectors. One of the primary operating principles of BEE is to achieve active participation and collaboration of all relevant stakeholders to bring about a fast and sustained implementation of energy efficiency. The key strategies of BEE include energy efficiency standards and labelling of equipment and appliances, energy conservation codes for buildings, energy conservation norms and goals for energy-intensive industries, and awareness raising and capacity-building.

BEE is playing a crucial role in India's energy-related GHG emissions reduction and avoidance by promoting energy efficiency adoption. BEE formulates cross-cutting policies and measures at the national level to cover major energy-consuming sectors such as industry, residential and commercial buildings, agriculture, transport, etc. The implementation of energy efficiency schemes steered by BEE is estimated to have resulted in total GHG emission reductions of around 177.6 million tonnes in 2019-20[30].

3.1.2. Legislative Framework

Recognizing the relevance of energy optimization in addressing the entwined goals of energy security, energy access, and climate change mitigation, the Government of India (GOI), introduced the Energy Conservation (EC) Act[31] in 2001. The primary objective of the EC Act is to promote energy efficiency and alleviate the energy intensity of the Indian economy. In order to institutionalize the implementation of energy efficiency and facilitate the delivery of the goals of the EC Act, BEE was established in 2002 as the nodal central statutory body under the Ministry of Power. The EC Act provides the legal mandate, institutional structures, and regulatory mechanisms for BEE's policies and strategies at the national and state levels. The Act empowers BEE to organize policies and programmes to achieve effective energy utilization, determine and design energy utilization standards for sectors, recommend energy efficiency measures, monitor and verify energy efficiency improvements, and notify and penalize the defaulters. In addition, the Act also directs relevant state agencies and organizations to coordinate

[29] BEE is a quasi-regulatory authority set-up by Indian Government for implementing and promoting energy efficiency initiatives within the regulatory framework of the Energy Conservation Act, 2001. BEE also functions as a policy advisory body to the central and state governments for mitigating barriers for market transformation in energy efficiency.
[30] BEE. (2021). Impact of Energy Efficiency Measures for the Year 2019-20.
https://beeindia.gov.in/sites/default/files/BEE_Final%20Report_Website%20version.pdf
[31] GOI., (2001). Energy Conservation Act 2001.
https://beeindia.gov.in/sites/default/files/The%20Energy%20Conservation%20Act%2Cchp1.pdf

with the activities of BEE and promote energy efficiency in the states. BEE under the EC Act is also empowered to promote research and development to undertake energy conservation.

Furthermore, BEE is spearheading the implementation of energy efficiency activities outlined under the country's National Action Plan on Climate Change (NAPCC). BEE, along with other local organizations such as the Energy Efficiency Services Limited (EESL) organizes and implements flagship schemes and programmes as part of the Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE),[32] one of the key missions of the country's NAPCC.

3.1.3. The Indian NSI: Actors and Institutions, and their Drivers, and Gaps

Energy governance in India is multi-layered, due to the federal structure, and complex. A range of government actors operate in this area, interacting with a highly diverse end-user group, which diverges in terms of energy needs and incomes, user categories, etc. Actors include different ministries at the central and state levels (such as power, petroleum, coal, renewable energy, environment, etc.), public agencies (such as Central Energy Regulatory Commission, CERC; State Energy Regulatory Commission, SERCs; central and state transmission utilities, etc.) as well as private organizations (industry, etc.). Therefore, implementing any policy strategy or programme is challenging.

The Indian NSI is still emergent and fragile; actors lack capacities, access to knowledge and finance is limited, policy frameworks are weak and inconsistent, and the interaction among actors is inadequate.[33] In recent times, the policy framing in the energy sector has been predominantly driven by the twin goals of managing rising energy needs and curtailing GHG emissions from energy generation and consumption. Consequently, the Indian energy sector is undergoing a significant transformation towards renewables and enhanced energy efficiency.

Despite its merits, implementing energy efficiency in India is quite challenging.[34] Like other developing regions, market failures such as lack of awareness, insufficient access to technology and funds, high transactions costs, limited technical and institutional capabilities, perceptions of high investment risks, etc., make the process difficult.[35] Moreover, factors such as flawed energy pricing and procurement practices, non-internalization of the environmental costs, a lack of life-cycle analyses, difficulties in assessing costs and benefits of energy efficiency, considerations of rebound effects, etc., make the designing of energy efficiency policies quite tricky. Divergences in energy efficiency performance across the Indian states and industrial sectors do not help the situation either.[36]

3.1.4. Description of the initiatives

The following paragraphs discuss three leading programmes being implemented by BEE, resulting in significant energy savings and GHG abatement.

Standards and Labelling Programme (S&L)

BEE launched its Standards and Labelling (S&L) programme in 2006 to promote appliance energy efficiency and provide the consumers an informed choice about the energy and cost-saving potential of energy-efficient (star-labelled) products. The scheme has been invoked for 21 equipment/appliances (e.g. lights, refrigerators, etc.) so far. BEE recognized that to implement performance standards for appliances, three factors were indispensable:

- Definition of performance standards for equipment;
- An assured demand and supply of products;
- A supporting testing and services infrastructure.

Regardless of the entry of multinationals such as Hitachi, LG, Philips, Whirlpool, and other big names in the Indian market, the consumer appliance product category hardly had any energy-efficient products.[37] Moreover, absence of performance benchmarking (and standardization), and prevalence of small and medium units in the appliances manufacturing ecosystem resulted in wide deviation in the operational features[38] of appliances.[39] End-users were unaware of potential climate gains and

[32] ROSHANEE is the upgraded version of the earlier National Mission on Enhanced Energy Efficiency, NMEEE under India's NAPCC, https://beeindia.gov.in/sites/default/files/Roshanee_print%20version%282%29.pdf
[33] Rajan, Y. S. (2012). Shaping the national innovation system: The Indian perspective. The Global Innovation Index, 131-141.
[34] Singh, D., Sant, G., & Chunekar, A. (2012). Improving energy efficiency in India: need for a targeted and tailored strategy. Wiley Interdisciplinary Reviews: Energy and Environment, 1(3), 298-307.
[35] Sorrell, S., & O'Malley, E. (2004). The economics of energy efficiency. Books.
[36] Ministry of Power, GOI. (2019). India State Energy Efficiency Index.
https://beeindia.gov.in/sites/default/files/State-Efficiency-Index-2019%20%281%29.pdf
[37] Chaudhary, A., Sagar, A. D., & Mathur, A. (2017). Innovating for energy efficiency: a perspective from India. In Sustainability-oriented Innovation Systems in China and India (pp. 57-58). Routledge.
[38] For instance, voltage settings, wattage, run-time, idle-time, energy usage patterns, etc.
[39] Chaudhary et al., 2017

cost savings of energy-efficient appliances. However, BEE could foresee the immense potential for energy savings and GHG emission reductions from energy-efficient appliances in light of the growing appliances market in the country. In order to tap into this opportunity, BEE recognized that it was crucial to focus on four main actor groups: end-users, retailers, manufacturers, and testing and servicing professionals.

A first important task was to **create a demand for energy-efficient products**. To achieve this, intensive awareness-building efforts through publications[40] (promotional materials, newspapers, magazines, books, leaflets, etc.), electronic media,[41] social media,[42] radio,[43] television, etc., were undertaken. Awareness workshops, seminars, outreach programmes, and capacity building initiatives were undertaken. BEE also conducted retailers' training programmes to disseminate information on the merits of star-labelled products so that the retailers can persuasively motivate the consumers to opt for efficient products. To begin with, performance standards were defined for refrigerators and air conditioners (ACs) as these were the most energy-consuming appliances in the Indian context.

After buy-in from the end-users, it was important to effectively engage with the manufacturers and create an adequate testing and servicing infrastructure for energy-efficient equipment.[44] The creation of market demand and the definition of performance standards **instilled confidence among manufacturers and spurred innovation** and eventually led to market transformation. The 'technology-neutral' nature of the S&L programme lent the manufacturers the flexibility to innovate with technologies and processes. To develop a complementary infrastructure for testing, actors and resources were created using a 'multi-pronged' strategy. Government research organizations (CPRI, etc.), private actors, academic institutions (IIT Delhi, Bombay), etc., were brought in to set up testing facilities and define protocols. Sectoral experts, manufacturers, accreditation authorities (e.g., NABL), testing laboratories, standards bodies, consumer groups, etc., were also consulted before and during the firming up of the strategy and standards.

The programme also drew on **international experiences and resources** using the technical expertise of the Collaborative Labelling and Appliance Standards Program (CLASP) and funding opportunities (engagements with the USAID, USEPA, and UNF) provided by it.[45]

S&L followed a phased approach. It started as a voluntary programme for select products, which became mandatory for several product categories once market preparedness, consumer receptivity, and market penetration of efficient appliances increased.[46] In sum, the **design and focus areas of the S&L programme was strategically planned**. The specific gaps in the innovation system were recognized early on. Efforts were focused on creating the missing actors, resources, capabilities, and institutions. And in this process all significant elements and stakeholders of the overall innovation system were looped in for effective implementation of the programme.

Energy Efficient Lighting

Two main energy efficiency lighting programmes are covered here: Bachat Lamp Yojana, BLY and Unnat Jyoti by Affordable LEDs for All, UJALA.

Bachat Lamp Yojana (BLY) was launched under the Market Transformation for Energy Efficiency (MTEE) programme to promote the large-scale deployment of energy-efficient Compact Fluorescent Lamps (CFL) to replace incandescent bulbs. At the very start, BEE recognized that the higher price of CFLs could prove to be a significant deterrent to end users and accordingly worked out an innovative business model. BLY was developed as a Programme of Activity (PoA) under the CDM,[47] and the revenue from the carbon credits was leveraged to eliminate the price difference. BLY distributed CFLs at around INR 15 to the households in exchange of incandescent bulbs. Participation by households in the programme was voluntary. To make the market transformation smooth and effective, BEE facilitated Public-Private Partnerships (PPPs) between GOI, private CFL manufacturers, and state-level electricity distribution companies (DISCOMS). Thus, BLY was designed as a win-win proposal for all.

[40] For example, BEELINE, COFFEE TABLE BOOK, Corporate Brochures, Leaflet of each programme, Bachat ke Sitare, Laghu Pustika, posters/pamphlets/ stickers, calendars

[41] Messaging through SMS/Internet to create awareness on Energy Conservation Day

[42] Facebook, twitter, youtube, etc.

[43] Radio Spots in FM: - 156 episodes of “BachatKeSitare” were broadcast on AIR FM Gold

[44] Malhotra, A., Mathur, A., Diddi, S., & Sagar, A. D. (2021). Building institutional capacity for addressing climate and sustainable development goals: achieving energy efficiency in India. Climate Policy, 1-19.

[45] Malhotra et al., 2021

[46] CUTS CCIER. (2017). BEE energy star labelling program: Brief overview on implementation & success factors. CUTS Centre for Competition, Investment & Economic Regulation (CUTS CCIER).

[47] The PoA was registered at the UNFCCC in 2010.

BLY[48] was replaced by the Unnat Jyoti by Affordable LEDs for All (UJALA)[49] programme in 2014. Despite lower operating costs of LEDs and its GHG emission reduction potential, large-scale LED deployment was quite challenging because of the higher upfront costs of LEDs, limited awareness among the potential users, absence of policies incentivizing LED implementation, and apprehensions of some key actors (e.g., the DISCOMS).[50] Moreover, the lack of technical standards for LED lamps and their components posed a crucial gap that needed to be addressed before their market implementation.[51] Energy Efficiency Services Limited (EESL), the organization that spearheaded the programme under the guidance of BEE, worked out a 'demand aggregation-price crash model' to mitigate some of these gaps.[52] The **business model involved lowering costs by employing economies of scale through demand aggregation and bulk procurement** of LEDs.[53] Consequently, LEDs were distributed to the end-users at 40% discounted prices, without subsidies.[54] Furthermore, consumers were allowed to choose to pay total cost upfront or use the 'pay as you wish/on-bill financing' programme, with the costs included as monthly instalments in the electricity bill.[55] Government networks and infrastructure were utilized for the distribution of LEDs under UJALA.[56] To define energy efficiency standards for LEDs and their parts, BEE tapped into the experience of the S&L programme. An international expert group developed the standards which were adopted by the Bureau of Indian Standards (BIS).

Further, all relevant actors across the value chain (manufacturers, state utilities, local vendors, distributors, etc.) were given responsibilities, depending on their capabilities, and were directed to work according to **standard templates and processes** organized by the EESL.[57] In order to create early markets and build the confidence of the actors engaged in the process, BEE funded pilot installations of street lighting applications in selected regions. The resulting cost and energy savings encouraged stakeholders, including state government regulators, to have a buy-in in the programme and to scale it up further. The choice of street lighting as the focus of the pilot interventions had strategic relevance. Similar to the S&L programme, BEE **kick-started the programme with low-hanging fruit**, with the potential for maximum energy savings per investments or effort required. Beyond cost optimization and large-scale deployment, UJALA also managed to create an ecosystem for LED manufacturing ('localization of LED manufacturing')[58] in the country.[59]

Perform Achieve and Trade (PAT) Mechanism

The Perform Achieve and Trade (PAT) mechanism was launched in 2012 under the NMEEE as a market-based strategy to promote energy efficiency in industrial sectors in India. BEE is the overall regulator of the programme, with EESL as the implementing and monitoring agency. In spite of the availability of appropriate technologies and the potential for energy conservation and cost savings in the medium to long-run, energy efficiency strategies have not been very popular in the Indian industry. This has been due to a lack of information, access to funds for initial investments, long payback periods, the absence of incentive structures, etc.[60] The national energy management ecosystem also lacked qualified manpower to monitor and verify energy consumption in industrial units at a large scale. The PAT scheme was introduced to address some of these barriers and establish a 'methodology-driven', robust, transparent, and flexible mechanism to **incentivize the implementation of industrial energy efficiency** in a cost-effective manner.[61]

Under PAT, industrial units from energy-intensive sectors are selected, and unit-specific baselines and mandatory energy savings targets are defined. Sectoral baselines or similar approaches are considered problematic as the Indian industrial units within a sector display a wide range of efficiency levels[62]. Also, setting too strict energy standards could lead to units shutting down, whereas too lenient standards could facilitate the continuation of underperformance by industries. Penalties are levied

[48] Another factor for the discontinuation of the BLY was the fall in CER prices after the weakening of the CDM post 2012
[49] Also known as LED-based Domestic Efficient Lighting Programme (DELP)
[50] The distribution companies feared that energy efficient lighting could lead to losses, however, reduction in peak load demands due to efficient lighting in situations of energy deficit helped them better manage the energy demand.
[51] Malhotra et al., 2021
[52] IBEF. UJALA. YOJANA. https://www.ibef.org/government-schemes/ujala-yojna.(accessed on May 15, 2022)
[53] EESL procured LED bulbs over successive rounds of competitive bidding, manufacturers needed to submit technical and price bids according to pre-specified criteria by EESL.
[54] IEA. 2017. “India’s UJALA Story.” International Energy Agency (IEA). https://eeslindia.org/img/uajala/pdf/UJALA_Case_Studies_1.pdf
[55] IBEF. UJALA. YOJANA (2022)
[56] Chunekar, A., Mulay, S., & Kelkar, M. (2017). *Understanding the Impacts of India's LED Bulb Programme," Ujala"*. Prayas (Energy Group). https://www.researchgate.net/profile/Sanjana-Mulay/publication/349924839_Impact_of_India's_large-scale_LED_bulb_program/links/604789f492851c077f297fcb/Impact-of-Indias-large-scale-LED-bulb-program.pdf
[57] Malhotra et al., 2021
[58] Malhotra et al., 2021; Chunekar et al., 2017
[59] Mir, D. A., Doll, C. N., Lindner, R., & Parray, M. T. (2020). Explaining the diffusion of energy-efficient lighting in India: A technology innovation systems approach. Energies, 13(21), 5821.
[60] Bhandari, D., & Shrimali, G. (2018). The perform, achieve and trade scheme in India: An effectiveness analysis. Renewable and Sustainable Energy Reviews, 81, 1286-1295.
[61] Chaudhary et al., 2017; Bhandari and Shrimali, 2018
[62] Chaudhary et al., 2017

on non-compliance, while tradable energy saving certificates (ESCerts) are issued on over-performance, i.e. being more efficient than required under the standard. The market determines the prices of ESCerts, and over-performers can sell their certificates to those that do not comply with the standard. The 'technology-neutral' approach of BEE provided the required flexibility to the facilities to choose a pathway for energy conservation that was most suitable for them.[63]

The approach meant that BEE required plant-level energy data inventories to define baselines and energy-saving targets. To achieve this task, BEE engaged third-party energy auditors, most of whom were already working for BEE, and **conducted rigorous consultations with industry participants**. The industry consultations also helped shape the finer aspects of the mechanism's implementation. BEE created a Knowledge Exchange Platform to facilitate interaction among industry actors and in turn, peer-to-peer learning about best practices and technologies.[64] Furthermore, the PAT mechanism needed technically trained and accredited energy auditors, verifiers, and managers, for which BEE, along with EESL and other ESCOs, undertook an extensive training and accreditation to **create a pool of energy specialists.[65]**

PAT has been designed as a **dynamic and evolving scheme**, with each implementation cycle redefining the designated sectors/units and the energy consumption norms.[66] Over the course of the PAT cycles, the industrial units matured and felt incentivized to upgrade their capacities and infrastructures to achieve maximum energy savings. While PAT implementation was not without flaws,[67] it helped steer the industry towards efficient operations and created a technically trained human resources base to measure and monitor energy consumption in the industry.[68]

3.1.5. Assessment of the initiatives by BEE

A structure-function coupled assessment was done for the programmes discussed above to underscore how the initiatives have facilitated the delivery of systemic functions by enhancing the structural components of the Indian innovation system in the energy efficiency domain and eventually strengthening the country's NSI with respect to the overall energy use sector.

BEE is well aware of the strengths and weaknesses of the Indian energy innovation space. So, although the various programmes were designed to focus on enhancing the strengths and closing the gaps in line with the objectives and context of the intervention, BEE used some elementary strategies across its interventions. These common strategies were essentially some of the very determining systemic functions (particularly in the Indian context) that support crucial stages or structural elements of the innovation process, as discussed below.

Knowledge development, diffusion, and network impacts: All BEE programmes have a significant impact on knowledge generation, diffusion, and capacity building. Depending on the design and focus of the initiatives and the prevailing deficiencies in the innovation system, BEE ensures that relevant actors' technical, institutional, political, and financial capacity building (including the creation of new/trained actor groups) is at the core of the implementation plan.

BEE recognizes that innovation is a systemic affair: i.e., pockets of capable actors and institutions interspersed by actors/institutions lacking adequate capacities - a common feature in a developing country context - could undermine the overall effort. BEE also acknowledges that capacities are 'distributed across a range of actors and networks' comprising the innovation system. It is therefore critically important that effective interaction and exchanges between the various components of the system[69] take place along the innovation cycle. For example, BEE takes special effort to engage relevant research organizations and academic institutions to leverage their domain expertise besides providing a sound, scientific basis and backing to its interventions. The creation of the Knowledge Exchange Platform under the PAT mechanism or the PPPs in BLY are other examples of such interaction between components and actors along the cycle.

Most of the initiatives have built-in procedures for monitoring and verifying outcomes. This supports a sustained delivery on the goals, in addition to helping to pinpoint missing links or gaps in the system. BEE acknowledges the cumulative nature of knowledge creation and capacity building and ensures that all relevant actors and networks have ownership. The strategies have a forward-looking and flexible outlook and adapt to the changes in the policy, market, and technology domains in the country and beyond.

Entrepreneurial experimentation and market formation: To improve risk perceptions that affect the willingness of actors and to seek their buy-in to the programmes, BEE has worked out innovative governance and market models using no regret/win-

[63] Chaudhary et al., 2017
[64] Bhandari and Shrimali, 2018
[65] Chaudhary et al., 2017; Malhotra et al., 2021
[66] Sarangi, G. K., & Taghizadeh-Hesary, F. (2020). Unleashing market-based approaches to drive energy efficiency interventions in India: An analysis of the Perform, Achieve, Trade (PAT) Scheme (No. 1177). ADBI Working Paper Series
[67] e.g. in target definition, baselines, lack of clarity and consistency in methodology.
[68] Bhandari and Shrimali, 2018; Sarangi and Taghizadeh-Hesary, 2020
[69] Primarily policymakers, technology developers and manufacturers, industry and household users, financial agencies, knowledge institutions, etc.

win approaches[70]. For instance, the design of BLY or UJALA was such that every actor engaged in the programme felt incentivized: end-users and manufacturers could foresee the energy savings and the financial gains. The UJALA programme worked out a 'demand aggregation-price crash model' to bridge the price gap between LEDs and conventional lighting. The end-users, over and above the savings in their electricity bills, got the LEDs at 40% discounted prices, and had the option to make the payment in one go or over time. In the street lighting programme, pilot or demonstration initiatives were run to instil confidence among stakeholders. BEE generally followed a technology-neutral approach in situations that demanded product or process-level innovations by manufacturers. This provided manufacturers the flexibility to opt for energy conservation pathways most suitable to them. Such innovations in governance or market structures alleviated the stakeholders' risk notions and facilitated the formation of early markets and, eventually, market transformation.

Resource mobilization and development of positive externalities: For each of its initiatives, a crucial element of BEE's strategy was to identify the factors which could determine the effectiveness or the scale of the intervention and ensure that a complementary, system-level infrastructure[71] is developed. For instance, the development of energy auditors/managers in the PAT mechanism, performance standards for LEDs or appliances (for UJALA and S&L respectively), or testing facilities for the S&L programme, etc. were unambiguously aimed at making sure that an enabling, complimentary ecosystem is generated to implement the programme in a robust, sustained and effective manner. Furthermore, BEE ensures that each programme is backed by the right kind of institutional framework, in the form of policies and regulations to provide direction to the energy efficiency initiatives, systems and procedures to measure, monitor and verify energy efficiency, coordination between different policies and governance structures, and leveraging multilateral and bilateral policy structures and collaborations.
BEE also taps into international expertise, experience, and (technical and financial) resources to enhance the effectiveness and reach of its initiatives. International experiences related to implementation schemes, market models, regulatory structures, etc., have not been copied, but have been adapted to suit the Indian realities on the ground.

Legitimation: BEE followed two fundamental strategies to develop credibility and legitimacy for its programmes. First, most of the BEE programmes started as voluntary initiatives. After achieving a certain degree of consumer receptivity and market preparedness, voluntary standards were made mandatory with a broadened scope. Second, BEE's choice for specific sectors or interventions early on was not incidental, but the result of strategic thinking on minimising risks and maximising gains with limited efforts). From the very start, BEE recognized the need for a nuanced understanding of energy consumption patterns in the country and the energy efficiency improvement potential in different sectors and applications. Accordingly, given limited resources and capabilities, BEE prioritized its efforts and assets towards interventions that could accrue maximum energy savings and GHG emission reductions ('biggest bang for the buck'). This was for instance based on analyses of the largest energy-consuming sectors and activities (industry, households), as well as those with the highest growth rates (e.g. electricity-using equipment in households, such as AC, fans, appliances). As a result of BEE's strategic prioritization and design of energy efficiency interventions (along with other factors), between the years 2011 to 2019, the country's energy intensity has decreased from 65.5 toe per INR crore to 55.5 toe per INR crore, and annually 177.6 MT of CO_2 emissions have been reduced (AEEE, 2021[72]).

Table 5 below presents the summarized findings of the structure-function coupled analysis of BEE as an organization.

[70] Cost-effective or low-cost strategies with climate gains and other co-benefits without any hard trade-offs with other policy objectives, etc.
[71] knowledge infrastructure, financial infrastructure, physical infrastructure
[72] https://aeee.in/wp-content/uploads/2021/05/India's-Energy-Efficiency-Landscape-Report.pdf

Table 5: Structure-Function Coupled Analysis of BEE's Initiatives

Function		Structural element	BEE's interventions
F1	Knowledge develop-ment and diffusion	Actors	• Awareness-building programmes created an informed user base for energy efficiency • 'Technology-neutral' nature of the programmes lent innovative flexibility and promoted innovation by manufacturers
		Institutions	• Energy saving targets, performance standards for appliances, LEDs, etc., created much-needed institutional backing for promoting energy efficiency and healthy competition in the market • Design of the institutions[73] was iterative, meaning that standards were periodically revized/upgraded, going from voluntary to mandatory
		Interactions	• Trust building between actors facilitated interactions/learning between all relevant actors in value chain, leading to network impacts • Respective capabilities of different actors were utilized (e.g. academic and research institutes were engaged in definition of standards for S&L; distribution companies infrastructure was used facilitate distribution of LEDs in UJALA; energy auditors were engaged in the creation of energy data inventory in PAT, CLASP was brought in S&L to define standards, mobilize international funders, etc.) • Actor interactions facilitated by BEE promoted knowledge diffusion, peer-to-peer learning, and promotion of best practices • Specific Knowledge Exchange Platforms were created for shared learning • Foreign expertise and resources were also looped in (e.g., CLASP, US EPA, US AID, etc.) • PPPs were formed to minimize risks and capitalize on the respective capabilities of different actors (e.g. UJALA)
		Infra-structure	• Complementary infrastructure was created (e.g. testing/services infrastructure for S&L, human resources, energy auditors for PAT; retailers training programmes for S&L, etc.) • Energy data inventories were created as part of the programmes (e.g. PAT), helping in designing future interventions in a more informed and scientific manner
F2	Entrepre-neurial experi-mentation	Actors	• The 'technology-neutral' nature of the programmes lent flexibility to the manufacturers
		Institutions	• Phased and evolutionary approach promoted experimentation
		Interactions	• Respective capabilities of stakeholders were tapped into to create rigorous, sustainable, and attractive business models (e.g., for UJALA diverse stakeholders were made to work together and each actor felt incentivized) • Foreign expertise and resources were also looped in (CLASP, USAID, USEPA, UNF, etc.)
		Infra-structure	n.a.
F3	Market formation	Actors	• Awareness raising across programmes helped in creating market demand • Innovative business models to sustain the demand-supply dynamics (e.g. PoA in BLY; demand aggregation in UJALA) • Business models were designed in a manner such that (perception of) risks are mitigated, gaps are bridged, and each actor feels incentivized (e.g., BLY, UJALA distribution models)
		Institutions	• Phased approach (first voluntary standards/limited coverage, mandatory/broader coverage over time) helped market transformation
		Interactions	• Networks between all relevant actors (e.g., in UJALA, standard bodies, manufacturers, state utilities, local vendors, distributors, etc.) created for effective implementation

[73] This refers to the rules or norms governing organizational and individual patterns of behaviour within the innovation system, the definition used in innovation studies.

			• PPPs between government agencies, private manufacturers, state electricity distribution companies (e.g. in UJALA) led to effective market transformation • Actor exchanges induced peer-to-peer learning and healthy competition in the market
		Infra-structure	• Use of carbon markets (e.g. BLY), demand aggregations (e.g. UJALA), innovative payment generation mechanisms (e.g., BLY and UJALA), auction mechanisms for manufacturers (e.g., UJALA) helped create supporting market infrastructure • Creation of complementary capabilities, systems and infrastructure helped in market formation (creation of energy managers/auditors for PAT, testing infrastructure for S&L; LED manufacturing industry for UJALA, etc.) • Protocols and standards for manufacturers and other actors participating in the value chain were defined (e.g., in UJALA), providing a basis for more systematic and monitorable interventions in the future • Use of pilot programmes to develop early markets (e.g., UJALA street lighting programmes)
F4	Influence on direction of search	Actors	• The 'technology-neutral' nature of the programme lent flexibility to the manufacturers to innovate (in processes and products) according to their preferences
		Institutions	• Definition of energy saving targets, performance standards, etc. promoted innovation and R&D
		Interactions	• Interaction among industry actors disseminated information on best practices and steered innovation and R&D
		Infra-structure	n.a.
F5	Resource mobilization	Actors	• Capacity building of human resources to support the programmes (e.g., energy specialists for PAT, testing and servicing infrastructure for S&L, PPPs for UJALA • Capacity of retailers upgraded to support the promotion of energy efficient equipment • Assured market gains and demand encouraged the manufactures to invest
		Institutions	• Energy savings targets, performance standards, etc. made investments by the industry/ manufacturers obligatory
		Interactions	• Interactions among (national and international) stakeholders helped in pooling human expertise and finances
		Infra-structure	• Complementary testing and servicing infrastructure was developed • Use of carbon markets (e.g. BLY), demand aggregations (e.g. UJALA), innovative payment generation mechanisms (e.g., BLY and UJALA), auction mechanisms for the manufacturers (e.g., UJALA) helped mobilize resources
F6	Legitimation	Actors	• Evolutionary nature, gradual tightening the programme (voluntary to mandatory) helped build credibility and legitimacy among actors
		Institutions	• The legal and political backing of the energy saving targets and EScerts made the PAT design rigorous and legitimized the interventions • Phased approach and gradual broadening of coverage of the programme helped cumulative learning and error corrections in the institutional domain and maximized climate mitigation (e.g., S&L, PAT, etc.) • Selection of focus sector/area/equipment is also strategic, particularly in the initial phase of the programmes– easy to implement, monitor and verify with maximum climate gains (e.g., focus on home appliances in S&L, large industries in PAT, lighting in UJALA)
		Interactions	• Interactions among actors helped in spreading the word on the merits of EE appliances
		Infra-structure	• Creation of complementary infrastructures (human resource and physical infrastructures) also enhanced the credibility of BEE as an organization and its programmes (e.g., PAT, S&L, etc.)
F7		Actors	• Creation of market demand enticed the engagement of manufacturers

	Develop-ment of positive externalities		• The 'technology-neutral' nature of the programme lent flexibility to the manufacturers
		Institutions	• Definition of standards, benchmarks, targets created the institutional infrastructure for effective and ambitious implementation
		Interactions	• Interactions between technology providers, financiers, manufacturers, retailers, users, and policy makers created trust and an enabling environment to implement and scale-up interventions
		Infra-structure	• Complementary infrastructure, including skilled manpower, energy specialists, testing and servicing ecosystem, (both human resource and physical infrastructure) was created • Creation of demand and supply promoted the financial infrastructure • Implementation of programmes helped develop local manufacturing ecosystems (e.g., LED manufacturing in UJALA, energy efficient appliances manufacturing in S&L, etc.) • Institutional and policy incentives motivated actors involved

3.1.6. Role of the BEE's initiatives in India's NDC

The government, in its effort to align and consolidate BEE's initiatives with the NDC, has launched the Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (ROSHANEE), which is essentially a broader version of the NMEEE. ROSHANEE includes all the current and potential interventions related to energy efficiency in various economic domains. BEE then devized a strategic plan called 'Unlocking National Energy Efficiency Potential (UNNATEE)' to fulfil its obligations under the NDC by 2030. UNNATEE includes a framework and implementation strategy in the short, medium, and long term to ascertain a straightforward linkage between energy demand scenarios and energy efficiency opportunities with the overall energy efficiency targets for the country. The implementation strategy identifies newer potential opportunities besides focusing on the ongoing programmes by BEE.

The NSI reinforced by BEE can form a stepping stone for broadening and deepening of the energy efficiency interventions in various ways. For instance, the actors already engaged in programmes such as PAT or Energy Conservation Building Code (ECBC[74]) can align their portfolios and activities with the NDC targets in a straightforward manner. As part of its current programmes, BEE has made considerable progress in strengthening the Indian innovation system, creating a favourable regulatory and policy regime, and coming up with innovative market and business models to implement energy efficiency in the country. Moreover, in sectors engaged in BEE programmes, the process of building capacities (human resources, technological capacities, industrial and supplementary infrastructures) and pooling in of resources and expertise (including international collaborations) is already at a significant level. Streamlining them further with an ambitious outlook to cover more sectoral GHG abatement opportunities could contribute extensively to the NDC.

3.1.7. Key success factors and lessons learned

BEE's experiences hold several valuable lessons with potential for emulation in similar contexts. The main lessons from BEE's story can be summarized as follows:

A tailored approach is required as innovation needs vary: BEE recognized that innovation is a complex, multi-actor, multi-level process which mandates a combination of cross-cutting activities (say at the national level) and sectorally and geographically focused (customized) strategies. Comprehensive energy efficiency initiatives aiming to cover 'all sectors and subsectors' through single policy directives yield limited results as the already limited resources get spread too thinly across target areas, resulting in unimpressive outcomes. Accordingly, although BEE is engaged in a range of technological domains and initiatives, each programme has been customized to cater to sector- or domain-specific challenges and needs. In doing so, BEE has developed a diverse set of strategies, including technology-push and market-pull strategies, rewards and penalties, loans and waivers, etc.

Bridging sector-specific gaps is key: BEE, through experience and learning, developed an intensive understanding of the failures and gaps in the Indian energy innovation ecosystem. Consequently, the Bureau's interventions have been designed to bridge those gaps and strengthen the weaker links in the system. For instance, the development of energy auditors/managers in the PAT mechanism, the performance standards for LEDs or appliances (for UJALA and S&L respectively), and the testing facilities

[74] The Energy Conservation Building Code (ECBC) is an initiative being undertaken by the BEE (under the EC Act, 2001) to promote energy efficiency standards in commercial and residential buildings. ECBC was first launched in 2007 for new commercial buildings, but it has been revized and upgraded (e.g. in 2017) thereafter to include the residential sector, etc. (refer to https://beeindia.gov.in/content/buildings for more details).

for the S&L programme were unambiguously aimed at making sure that an enabling ecosystem is generated to implement the respective programme in a robust, sustained and effective manner.

Innovation activities need to be strategic, iterative and evolutionary: From the very start, BEE acknowledged the evolutionary nature of innovation processes. BEE's initiatives were revised and upgraded in response to technological developments, market transformations, political mandates, collaborative learning, international influences, upgrading actor capabilities, evolving user needs, etc. For instance, the S&L programme gradually broadened its scope (in terms of equipment/sectors covered) as the market matured and the scheme garnered greater acceptance by end-users. Similarly, the CFL programme under BLY was aptly replaced by UJALA as LED technology was more energy-efficient than CFLs.

BEE's choice or prioritization of the focus sectors has also been strategic. The Bureau has prioritized its efforts and assets towards interventions that could accrue maximum energy savings and GHG emission reductions ('maximum bang for the buck'). This logic has driven BEE's focus on industry, buildings, appliances, etc.[75]. Besides resource optimization and delivery of maximum gains, this approach has also helped build the implementing agency's credibility and legitimacy.

Coordination and integration of NSI elements is crucial: BEE's story highlights the role and efficacy of a coordinating agency ('system operator/aggregator') in initiatives with multiple goals (innovations for sustainability: energy saving, GHG mitigation, energy security, etc.), multiple sectors, and multiple actors. BEE as the coordinating agency assesses the domain-specific gaps, designs programmes to alleviate them, takes on board multiple perspectives of different actors, undertakes institutional framing to support the activities, facilitates interactions between actors, encourages market formation, and taps into international expertise and funds. Moreover, BEE builds on to the experiences and learnings of one programme to better design the subsequent initiatives making the process cumulative and evolutionary. As the 'system integrator' with a 'bird's-eye-view' of the overall Indian innovation system in the energy domain, BEE undertakes trust building exercize and facilitates synergistic engagement of the different structural elements (technology providers, financiers, technocrats, policy makers, end users, etc.) to develop effective networks. A deep and empirical understanding of the Indian innovation space helps BEE design innovative governance and market models that are win-win for all. Consequently, after the initial trigger and push by BEE and policy incentives, energy efficiency initiatives become self-sustainable, successful business models and lead to cascading impacts (delivery of systemic functions) in the overall innovation system.

3.1.8. Good practices for potential replication

Based on the above lessons learned from the BEE case, the following good practices can be identified that could lend themselves for replication in other countries:

- Map the NSI before designing and implementing strategies: It is crucial to obtain a deep understanding of the structural elements and functions of the sector-specific innovation system, the GHG mitigation opportunities vis-à-vis costs and technologies required at the sectoral or country level, main actor groups, the state of resources and capabilities, barriers and missing links in the innovation ecosystem, potential synergies and trade-offs with other initiatives and policy structures, and the role of international collaborations.
- Look for win-win measures: It is important to design win-win strategies (through innovative governance and market models) to ensure participation by all relevant stakeholders and minimization of the risk factors.
- Coordinate and integrate with local needs and the local agenda: It is essential to ensure that the initiative is in synergy and integrated with the overall policy framework of the country and that it facilitates the larger development and climate objectives of the region.
- Learn iteratively, be adaptive: Design learning mechanisms so that the impact of the strengthening of functions and the structural elements or a change in the characteristics (opportunities, strengths, needs, etc.) of the context in which the initiative is being implemented can lead to further strengthening in an iterative way.
- Create complementary knowledge and servicing infrastructure: In order to promote and implement technological innovations effectively and consistently (in the long term), the creation and sustenance of complementary knowledge, skill sets, and trained human resource base must be facilitated. This will also aid in monitoring, measuring, and upgrading technological innovations.
- Allow flexibility to achieve policy: This is particularly relevant in a developing country context. Where possible, the policy goals and aspirations need to be highlighted, and the stakeholders could be given the flexibility or leeway to choose or adopt the technology/means best suited to them to achieve those goals (e.g. be technology-neutral). This will generate

[75] As per 2021 statistics, the industry sector accounts for the lion's share, with 41% of the total energy consumption, followed by the domestic sector with 26%[75]. Similarly, owing to near-universal household connectivity to electricity and rising incomes, the electricity consumption in the buildings sector has almost doubled in the past decade (IEA, 2021). Moreover, the energy use in buildings is primarily driven by lighting, fans, and appliance use.

credibility for the regulator's actions, manage risk perceptions of the stakeholders, and facilitate faster attainment of the policy goals.

- Establish a clear role for a 'system-integrator' or coordinating agency: In situations where diverse stakeholders need to come together to make an intervention/innovation effective, the role of coordinating agencies or 'system operators/integrators' becomes important. Coordinating agencies with a holistic understanding of the strengths and flaws of the overall innovation system of the country can organize the actions of different stakeholders, address the system gaps, tap into the system resources and respective strengths of the actors, and maximize the network impacts.

3.2. CASE: Kenya Climate Innovation Center

Country	Kenya	**Focus**	Mitigation & adaptation
Scope	Adaptation and mitigation	**Key innovation system functions**	F1 Knowledge development and diffusion F2 Entrepreneurial experimentation F3 Market formation F5 Resource mobilization
Approach	Top-down	**Starting year**	2012

3.2.1. Introduction of the Initiative

The Kenya Climate Innovation Center (KCIC) was launched in 2012, to develop a 'cutting-edge facility' to promote innovative climate change solutions and sustainable development in Kenya by supporting the development, deployment, and transfer of locally appropriate climate and clean energy technologies.[76]

KCIC aims at both mitigation and adaptation benefits in the long term with a specific focus on renewable energy, clean water, agriculture, and energy efficiency. Initiatives targeting reductions in GHG emissions and enhanced access to clean energy lead to emission reductions while impacts on livelihoods and other socio-economic sectors augment the adaptive capacity of the local population.[77] To do so, KCIC provides incubation, capacity building, and funding to endeavours aiming at innovation in off-grid energy, renewable energy, agriculture and agribusiness, water management, commercial forestry and waste management. Accordingly, the Center delivers a mix of socio-economic and environmental outcomes, including GHG emission abatement, improved climate resilience, livelihood generation, and enhanced access to clean energy and safe drinking water. KCIC also promotes technology transfer and local innovation through private sector engagement, business model refinement, and market entry. The Center is engaged in mainstreaming SDGs and climate change in the country as one of the institutions supporting innovations in clean technology. It is estimated that through its interventions the Center has helped abate over 300,000 tonnes of GHG emissions so far.

3.2.2. Legislative framework

The Kenyan CIC was not established as a result of specific Kenyan legislation, but set up as an international initiative. The concept of the 'Climate Innovation Centers' (CICs) was developed in 2010 in the report 'Climate Innovation Centers - A New Way to Foster Climate Technologies in the Developing World', a joint effort by UNIDO, the UK Department for International Development (DFID), and infoDev, the World Bank's global partnership programme. KCIC is the world's first CIC in a global network of CICs being established by infoDev's Climate Technology Program (CTP).[78]

From its start till 2016, the Center operated as a consortium of four diverse institutions – private consultancy PricewaterhouseCoopers (PwC), Strathmore University, international NGO Global Village Energy Partnership (GVEP) International, and Kenya Industrial Research and Development Institute (KIRDI), a government institution mandated to promote industrial research and transfer of innovative technologies for social-economic development. Since then, the Center has evolved to function as a local, independent, non-profit company, having developed capabilities to fundraise its activities beyond the initial support.[79]

[76] *UNIDO. The world's first Climate Innovation Centre launched in Nairobi, https://www.unido.org/news/worlds-first-climate-innovation-centre-launched-nairobi (accessed on May 10, 2022)*

[77] KCIC. About Us, https://www.kenyacic.org/about-us/ (accessed on May 5, 2022)

[78] infoDev (www.infodev.org) is a global partnership programme within the World Bank Group which works at the intersection of innovation, technology, and entrepreneurship to create opportunities for inclusive growth and job creation.

[79] In 2016, KCIC was registered as an independent company limited by guarantee. From September 2012 to May 2016, the Centre's activities were funded by UK AID and DANIDA through the World Bank. From June 2016 to December 2020, the Centre received financial support from DANIDA for its interventions.

Aside from the KCIC, Kenya's research system is still developing, with only a draft science, technology and innovation (STI) policy (2008).[80] However, Kenya's national strategies for STI are well-defined in other legislative documents.[81] The national research policy has three main components:

- Vision 2030, which describes the country's development programme from 2008 to 2030;
- The National Science, Technology and Innovation Act 2013, which launched the national research institutions with a goal of implementing Vision 2030 and the STI plan; and
- The Universities Act of 2012, which directs universities to produce and disseminate scholarly research and promote innovation.

In light of KCIC's engagements in furthering SDGs and climate action in the country, in 2018, the Kenyan government recognized KCIC as the official implementing agency of the Promote Climate Technologies and Innovation initiative under the Kenya Vision 2030 Medium Term Plan III (MTP III, 2018-2022).[82] The Vision 2030 Delivery Secretariat signed a Memorandum of Understanding (MoU) with KCIC to explore opportunities for facilitating the implementation of climate technologies and innovation in Kenya. The primary task of KCIC under the MTP III is to support clean technology innovations.

3.2.3. The Kenyan NSI: Actors, Institutions, Drivers, and Gaps

Kenya has a reasonably moderate science, technology and innovation capacity in Africa.[83] Of the country's GDP, 0.8% is spent on R&D; however, 47% of the domestic R&D expenditure comes from international sources.[84] In recent times, there have been efforts to bolster the NSI by creating innovation hubs, incubators, industrial parks, Centers of Excellence, technology cities, and the promotion of private sector investment in R&D initiatives.[85]

The institutional framework for research primarily comprises the National Commission for Science Technology and Innovation (NACOSTI), the National Research Fund (NRF), and the Kenya Innovation Agency (KENIA).[86] Most of the institutional framework for innovation in the country was established between 1992 and 2012.[87]

Although the national institutions have explicit visions and mandates, constrained financial capacity limits effective policy implementation, the performance of research organizations and the overall capacity of the national actors.[88] Many international research organizations[89] and intermediary organizations are located in Kenya, making the country a significant research centre in the East African region.[90] Consequently, knowledge transfer practices and intellectual property protection systems are reasonably well developed. However, these capacities are confined to a limited number of research organizations, and most research agencies and universities lack the funds and the capacity to undertake knowledge development and dissemination activities.

In terms of green entrepreneurship, a need assessment study by the World Bank revealed five main challenges, where such enterprises needed support in Kenya:

- A lack of skills, tools, and insights to translate ideas into successful businesses;
- Access to finance, including early-stage risk financing to enable high-potential start-ups to speed up their evolution;
- Access to information;
- Lack of an enabling business environment, due to the absence of a complementary policy framework or existence of unfavourable regulations on quality standards, taxation, etc.;

[80] Ministry of Science and Technology, Republic of Kenya. (March 2008). Science, Technology and Innovation Policy and Strategy. http://www.ist-africa.org/home/files/kenya_sti-policy_mar08.pdf (accessed on May 5, 2022)
[81] UKDFID. (October 2019). Assessing the needs of the research system in Kenya. Report for the SRIA programme. https://assets.publishing.service.gov.uk/media/5ef4acb5d3bf7f7145b21a22/NA_report_Kenya__Dec_2019_Heart_.pdf
[82] KCIC. https://www.kenyacic.org/2018/02/partnership-to-promote-clean-technologies-and-innovations/ (accessed on May 7, 2022)
[83] Kahn, M. J. (2022). The Status of Science, Technology and Innovation in Africa. Science, Technology and Society, 09717218221078540.
[84] UNESCO. 2016. UNESCO Science Report: Towards 2030. Paris: United Nations Educational, Scientific and Cultural Organization http://data.uis.unesco.org/index.aspx?queryid=68 (accessed on May 7, 2022)
[85] Yongabo, P., & Göransson, B. (2022). Constructing the national innovation system in Rwanda: efforts and challenges. Innovation and Development, 12(1), 155-176.
[86] UKDFID, 2019.
[87] Wachinga, H. (2019). National Innovation System Factors, Incentives, Culture and Institutional Linkages in Kenyan ICT Innovation Firms (Doctoral dissertation, UoN).
[88] UKDFID, 2019.
[89] The headquarters of international research organizations and think tanks such as the Royal African Society, the Pan-African University (public), the African Population Health Research Centre, the Africa Institute for Capacity Development, and the African Economic Research Consortium (private) are hosted by Kenya.
[90] UKDFID, 2019.

- Access to facilities which includes space for establishing business incubation hubs, training facilities, meeting and networking hubs (with peers, and investors), testing and demonstration facilities, manufacturing facilities, etc. [91]

Section 4 deals with these issues in detail and further elaborates on the drivers and gaps in the Kenyan innovation system.

3.2.4. Description of the initiatives

Since its inception, KCIC has been the 'go-to institution[92]' or 'one-stop-shop solution[93]' for organizing Kenyan activities aimed at innovative climate solutions to bring about economic development and green growth. In order to foster mitigation and adaptation activities, KCIC performs two fundamental functions – providing knowledge support and mobilizing funds. Accordingly, over time, the Center evolved in line with those functions and established a specialized venture fund (Kenya Climate Ventures, KCV) for funding-related activities and a consulting arm (KCIC Consulting, KCL). The role of these two entities is further elaborated below. First, we describe the types of activities KCIC has deployed to address the challenges mentioned above. Subsequently, the working areas in which these activities are being implemented are described.

Type of activities

KCIC has been promoting green entrepreneurship since its launch in 2012,[94] providing the following:

- To address the lack of skills, tools, and insights to translate ideas into successful businesses, KCIC provides mentorships to entrepreneurs in business management, technical assistance, and customized training to impart skills needed to convert their innovations into businesses.
- To improve access to finance, KCIC has devised three different types of funding mechanisms for different phases in the innovation cycle:
  - Proof-of-concept grants (up to USD 50000), as part of its incubation services.
  - Seed funding for projects with the potential to graduate from incubation towards becoming commercially viable (USD 50000-1M) and investment facilitation at more advanced stages of innovation. The Center devises innovative business and funding models to help companies overcome the 'valley of death' funding gap. To generate seed funding, among other strategies, KCIC launched the Kenya Climate Ventures (KCV) in 2016 with an initial World Bank grant. Presently KCV is 100% owned by KCIC, which had invested US$300,000 in convertible debt in the company by 2018.[95] The combination of KCIC as an incubator and KCV as a seed funder helps address the complexities of early-stage climate innovations, which are generally low on capital, high on risks, and have long-time-horizons.[96]
  - Early-stage risk financing to enable high-potential start-ups to speed up their evolution. KCIC set up an Early-Stage Finance Mechanism (ESFM).[97] The funding for the ESFM is sourced from the KCV or other potential investors. The ESFM lends support in the form of debt, equity, and hybrid instruments to cover the gap faced by early-stage businesses.[98]
- KCIC increases access to information by undertaking awareness-raising programmes to disseminate information on technologies, markets, knowledge, and technology transfer mechanisms, research updates related to different business sectors, and the adoption of green solutions.
- To address the lack of an enabling business environment, KCIC lobbies government ministries and agencies to push a pro-green entrepreneur agenda. The Center taps into the expertise of innovators, research and academic institutions, etc. to undertake policy advocacy and advise the businesses on regulations and related matters.
- KCIC works with its partners to provide improve entrepreneurs' access to facilities. For instance, the Center collaborated with Strathmore University Business School to set up the business incubation hub.

[91] Kiraka, R. N. (2021). Green Entrepreneurship: The Case Study of the Kenyan Climate Innovation Centre. In Responsible Management in Emerging Markets (pp. 83-106). Palgrave Macmillan, Cham.
[92] Gonzalez, A., Fruman, C., Tilmes, K., & Grown, C. (2016). Trade and competitiveness global practice gender practice note: FY17-20 (No. 120480, pp. 1-37). The World Bank.
[93] KCIC. Welcome to Kenya Climate Innovation Center, https://www.kcicgroup.org/ (accessed on May 4, 2022)
[94] Kiraka, 2021
[95] Mungai, E. (2018). Impact Investing in Africa: A Guide to Sustainability for Investors, Institutions, and Entrepreneurs. Springer.
[96] Ventures, K. C. Designing an Innovative Financing Model for Early Stage Clean Technology Companies. https://documents1.worldbank.org/curated/en/381371506073998670/pdf/119909-BRI-climate-technology-program-in-brief-7-designing-an-innovative-financ.pdf
[97] The success story of Acacia Innovations is one of the most popular achievements of the ESFM. https://www.kenyacic.org/2019/06/acacia-innovations-esfm-success-story/
[98] World Bank. 2018. InfoDev's Climate Technology Program Report for the July 2018 Steering Committee Meeting: FY18 Progress Report and FY19 Work Plan. https://www.infodev.org/sites/default/files/ctp-scm_report_2018.pdf

Through the above initiatives, KCIC supports green entrepreneurship at micro, meso, and macro levels.[99]

- Micro-level: Interventions at the level of individual enterprises, including capacity building, technical support, financial assistance, and mentorship to individuals and small and medium-sized enterprises.
- Meso-level: at the level of the value chain KCIC operates and supports the incubation hub, the accelerator hub, and the Seed Fund to address the funding needs of the enterprises. At this level, the Center provides business advisory on market development and policy-related strategies to businesses, investors, commercial banks, etc., to promote ideation, prototyping, and testing of products before scaling-up and commercialization. These interventions essentially aim at creating green enterprises along the value chain.
- Macro-level: at the policy and network level, KCIC collaborates with organizations such as the World Bank, international governments, the Kenyan Government, national and international academic and research institutions, etc., to provide policy advocacy and research support for green entrepreneurship. Here, KCIC engages in policy development, job creation, and building entrepreneurship culture, infrastructure, and support for research, education, etc., across multiple sectors.

Over the years, KCIC has marshalled more than $48 million (Sh5.4 billion) to support over 1,800 start-ups.[100] The start-ups are estimated to have generated about $32 million (Sh3.6 billion) in revenues, resulting in 25,000 indirect jobs and benefitting over 780,000 people.[101] Furthermore, KCIC undertakes special efforts to adopt an inclusive and gender-balanced approach in pursuit of its strategic goals.[102] For instance, the Center aims to support female entrepreneurs; at least 30% of its overall clientele list comprises women. Similarly, women-led agribusinesses are preferred. 60% of the total job opportunities created in the agribusiness sector are for women.[103] The Center trains, funds, and provides technical support to the women folk in sectors such as water, waste management, and commercial forestry.[104] Likewise, youth entrepreneurs are encouraged.

Working areas

The Center's working areas agri-business, renewable energy, water management, waste management and commercial forestry are each described below.

Agriculture and agribusiness

The agricultural sector in Kenya plays a very important role in terms of GDP, employment, export and as a source of industrial raw materials. However, it is hindered by smallholdership and untapped growth potential.[105] Smallholder farmers are relatively more vulnerable to climate risks such as droughts, floods, climate-induced pests and disease incidence, leading to productivity losses due to the degradation of agro-ecological systems (including soil and water).[106] Furthermore, Kenya's agriculture sector is heavily reliant on the country's bimodal rainy season.[107] Frequent droughts lead to severe crop losses, amounting to a loss of one out of every three seasonal crops. Only 1.7% of agricultural land is currently under irrigation.[108] Food and nutritional security continue to be a major concern for the country, particularly in the context of climate vulnerabilities, degrading soil quality, and the predominance of rainfed agriculture.[109]

To address some of these challenges, KCIC promotes enterprises that develop **innovative agricultural technologies and agribusiness models** that offer climate mitigation and adaptation benefits, increased productivity and diversification of production systems, and generate improved livelihood options for small-scale farmers. Some of the main agribusiness ideas supported by the Center include resilient crops/seeds, climate-friendly/energy-efficient agricultural machinery, efficient

[99] Kiraka, 2021
[100] E Mungai. (March 31, 2022). Reflecting on my decade at Climate Innovation Centre. https://www.businessdailyafrica.com/bd/lifestyle/society/reflecting-on-my-decade-at-climate-innovation-centre-3765716 (accessed on May 10, 2022)
[101] Mungai, 2022
[102] KCIC. (May 2018). KCIC_Communication_on_Engagement_Report_2016-2018. https://ungc-production.s3.us-west-2.amazonaws.com/attachments/cop_2018/464457/original/KCIC_Communication_on_Engagement_report_2016-2018.pdf?1528868807 (accessed on May 10, 2022)
[103] Government of Kenya (GOK). (2019) Guidelines for promotion, development and management of irrigation in Kenya. Ministry of Water, Sanitation and Irrigation: Nairobi, Kenya.
[104] KCIC. https://www.kenyacic.org/2022/03/women-at-the-forefront-of-a-sustainable-future/. (Accessed on June 25, 2022)
[105] Kenya Agricultural Research Institutions, KARI. 2019. https://www.kari.org/the-major-challenges/ (accessed on May 17, 2022)
[106] Osumba, J. J., & Recha, J. W. (2019). Scoping study brief-Potential for adaptation and mitigation. https://cgspace.cgiar.org/bitstream/handle/10568/107338/CCAFS%20Briefing%20paper%20-%20Potential%20for%20adaptation%20and%20mitigation.pdf?sequence=1&isAllowed=y
[107] KARI, 2019
[108] GOK, 2019
[109] Makini, F. W., Kamau, G., Makelo, M., Mose, L. O., Salasya, B., Mulinge, W., & Ong'ala, J. (2016). Status of Agricultural Innovations, Innovation Platforms, and Innovations Investment. 2015 PARI project country report: Republic of Kenya.

irrigation, energy-efficient food processing and climate-friendly alternatives for pesticides, fertilizers, grain drying and other field operations.[110]

One of the notable initiatives of KCIC in agriculture is the **AgriBiz** project, [111] launched in March 2021. The AgriBiz project aims to enhance food security, promote manufacturing by building on the strong links along the value chain in the sector, generate livelihood for women and youth, and set up business incubation hubs[112] to provide business advisory and financing services, and modernization of the agriculture sector. The project is a collaborative initiative of KCIC, DANIDA, the European Union, the African Development Bank, and the FAO. Some of the other significant interventions of KCIC and KCV in the agriculture sector have been listed in Table 6.

Energy

Kenya has a fast-growing energy sector, which is heavily dependent on biomass: around 68% of the country's energy needs are fulfilled by bioenergy (mainly wood).[113] It is estimated that Kenya can lose 65% of its forests for charcoal production by 2030.[114] Petroleum and electricity account for 21% and 9% of the country's total energy consumption.[115] Kenya does have significant renewable energy potential. In 2019, renewables contributed 74% of the total energy mix in Kenya.[116] The most critical challenges of the Kenyan energy sector include growing energy demand with an increasing gap between demand and supply, limited grid infrastructure, a lack of access to modern energy, over-reliance on biomass, and rising energy costs.[117]

To address these challenges, KCIC supports innovations that provide alternatives to traditional energy sources and reduce inefficient energy use in the domestic and industrial sectors. Some of the initiatives focus on off-grid technologies, including off-grid solar PV, biogas, biomass, and wind energy; micro-hydro for domestic and rural mini-grid use, and bio-energy using bio-gasification bio-diesel, biomass power, and heating. Some of the specific interventions of KCIC and KCV in the energy sector have been listed in Table 6.

Water and irrigation

In Kenya, water resources are scarce and characterized by a high degree of temporal and spatial variability resulting in over 80% of the land area being classified as arid/semi-arid.[118] Over 33% of the country's water resources originate outside of the country.[119] Around 15% of the Kenyan population is still reliant on 'unimproved' water sources such as ponds, shallow wells, and rivers, and 41% of the population lacks access to essential sanitation solutions.[120] Around 80% of the total water demand is derived from surface water, of which half is consumed for irrigation purposes.[121] Regions with sufficient rainfall to constitute productive agricultural land make up less than 20% of the country's land area.[122] Moreover, frequent droughts and floods worsen the situation with climate variability, increasing population, and escalating water demands further aggravating the problem.[123]

Over-extraction for irrigation poses threats to the sustainability of the surface water in several regions.[124] Groundwater is the primary source of water for domestic users not connected to public systems. Since agriculture is the backbone of Kenya's

[110] KCIC. Sectors that we support, https://www.kenyacic.org/sectors-that-we-support/ (accessed on May 2, 2022)
[111] KCL. Kenyan Farmers To Flourish From Sh5bn Agribusiness Fund, https://www.kcicconsulting.com/kenyan-farmers-to-flourish-from-sh5bn-agribusiness-fund/ (accessed on May 2, 2022)
[112] The project shall establish business incubation hubs in eight counties of Kenya including Uasin Gishu, Meru, Kisii, Nyeri, Bungoma, Isiolo, Kilifi, and Lamu.
[113] IEA. (2019). Africa Energy Outlook 2019: Overview Kenya. World Energy Outlook Special Report. https://iea.blob.core.windows.net/assets/44389eb7-6060-4640-91f8-583994972026/AEO2019_KENYA.pdf
[114] Onekon, W. A., & Kipchirchir, K. O. (2016). Assessing the effect of charcoal production and use on the transition to a green economy in Kenya. Tropical and Subtropical Agroecosystems, 19(3), 327-335.
[115] Takase, M., Kipkoech, R., & Essandoh, P. K. (2021). A comprehensive review of energy scenario and sustainable energy in Kenya. Fuel Communications, 7, 100015.
[116] Takase et al., 2021
[117] Takase et al., 2021
[118] USAID. 2021. https://www.usaid.gov/sites/default/files/documents/1860/Kenya_Power_Sector_report.pdf
[119] USAID. 2021
[120] Water.org, Kenya's water and sanitation crisis, https://water.org/our-impact/where-we-work/kenya/ (accessed on May 5, 2022)
[121] USAID. 2021
[122] USAID. 2021
[123] UNESCO. 2006. Kenya national water development report: case study. A WWAP case study prepared for the 2nd UN world water development report: Water, a shared responsibility (2006). UN-WATER/WWAP/2006/12. https://unesdoc.unesco.org/ark:/48223/pf0000148866
[124] USAID. 2021

economy, erratic and insufficient irrigation facilities have a knock-on effect on the overall economy.[125] Despite multipronged efforts to improve irrigation coverage in the country, only 16% of the irrigation potential had been achieved by 2018.[126]

KCIC is implementing a number of initiatives to address some of the challenges discussed above. In particular, the Center supports clients working on sustainable and efficient water management technologies such as solar filtration, desalination, water harvesting, efficient irrigation, biotechnology, and wastewater reuse and recycling.[127] Building on the technical expertise of other organizations, such as the Strathmore Energy Research Centre (SERC), KCIC facilitates the training of technicians in design, construction, and maintenance of water systems.[128] SERC provides training to KCIC's clients (mainly SMEs) to install and manage smart water metering solutions, water treatment, etc. Some of the specific interventions of KCIC and KCV in the water sector have been listed in **Table** .

Table 6: Some key initiatives supported by KCIC/KCV in the agriculture, energy, and water sector

Enterprise/ Organization	Sector	Technology	Support by
Aviva Kenya	Agriculture	NERICA (New Rice for Africa) - hybrid, drought-tolerant varieties, are suitable for low-input agriculture	KCIC
Hydroponics Africa	Agriculture	Hydroponic farming- growing crops in mineral nutrient solutions in water instead of soil (saves water)	KCV
Eco Sawa	Agriculture	Organic pesticides (e.g., Dane Bio Pesticide)	KCV
Agrihouse Solutions	Agriculture	Climate-smart farming technologies, e.g., greenhouse packages, shade net houses, water harvesting reservoirs, and irrigation systems	KCV
LishaBora Hydroponics	Agriculture	Hydroponic barley fodder	KCIC
Eco-burn Char Briquettes	Energy	Char briquettes from 95% recycled agriculture waste	KCIC
Tamuwa Ltd	Energy	Biomass briquette from bagasse	KCIC
Byster Enterprises	Energy	Construction and installation of biogas plants	KCIC
Smart Cook Energy Ltd	Energy	Bioethanol-based cooking technologies	KCIC
Powerspot Kenya Ltd	Energy	Converting cooking heat into thermal electric energy	KCIC
Bellac Research Consultants	Energy	Distribution of home biogas system	KCIC
Arimi tech	Water/ irrigation	Sensor-based automatic irrigation system for arid and semi-arid areas	KCIC
Takawiri Craft Enterprises	Water/ irrigation	Handmade stationery and craft items from water hyacinth	KCIC
SwissQuest Water Supplies Co Ltd	Water/ irrigation	Smart prepaid water metering solutions integrated with mobile payment systems	KCIC
Aqua Rescue Ltd	Water/ irrigation	Wastewater and water treatment solutions	KCIC
Maji Milele	Water/ irrigation	Prepaid water points	KCIC
AfricAqua	Water/ irrigation	Micro-distribution centres for water	KCIC
Taka Taka Solutions	Waste management	Developing high-quality compost from organic material; sorting of wastes for recycling industries	KCIC
Ecosave Africa	Waste management	Use of microbes to recycle waste in 'eco-treat waste digester'; detoxify urine before discharging into water systems, etc.	KCIC
Adarsh polymer Ltd	Waste management	Converts plastic waste into heavy oil, carbon black, and other clean energy solutions by pyrolysis	KCIC
Chemolex Limited	Waste management	Scoop plastic out of the rivers as they drift past	KCIC

Waste management

In the waste management domain, the Center facilitates the implementation of innovative methods and practices for the generation, storage, collection, transport, processing, recycling, and disposal of solid and liquid wastes. Clean technologies

[125] Silva, I. D., Ronoh, G., Maranga, I., Odhiambo, M., & Kiyegga, R. (2020). Implementing the SDG 2, 6 and 7 nexus in Kenya—A case study of solar powered water pumping for human consumption and irrigation. In International Business, Trade and Institutional Sustainability (pp. 933-942). Springer, Cham.

[126] Kanda, E. K., & Lutta, V. O. (2022). The status and challenges of a modern irrigation system in Kenya: A systematic review. Irrigation and Drainage.

[127] https://www.kenyacic.org/sectors-that-we-support/

[128] Silva et al (2020).

supported by the Center include waste separation and segregation at the source, engaging local communities, reducing waste toxicity, upcycling and recycling waste into reusable products, converting waste to energy, converting waste to compost, reduction of waste generation, etc. Some of the key initiatives supported by KCIC in the waste sector have been listed in Table 6.

Commercial forestry

In the commercial forestry sector, the KCIC is empowering innovations and practices that promote responsible forestry harvesting, afforestation, and re-afforestation and discourages the felling of trees under its GreenBiz Programme. The businesses supported by the Center focus on business models that engage local communities and include marketing of trees/tree products, thrust on tree species with commercial value, sustainable forest management, use of technology for monitoring of forests, creation of livelihood options, etc. KCIC has recently launched a project called Green Economy Youth Activation Programme (GrEYAP) with support from UNDP to promote commercial forestry in the country.[129] The GrEYAP project is aligned with the broader goals of Vision 2030 and aims to address the shortfall in the wood sector in Kenya. The country lost 10% of its forest cover from 2001 to 2018 despite the growth in wood import. The KCIC is providing incubation and mentorship to the GrEYAP project.

3.2.5. Assessment of the initiatives by KCIC

KCIC's interventions adopt a holistic approach vis-à-vis their working areas and they facilitate both mitigation and adaptation. This section assesses KCIC's role in the delivery of systemic functions, which have strengthened the Kenyan innovation system's structural components and contributed to the NSI. The following points discuss some of the vital systemic functions performed by KCIC.

Knowledge development and diffusion: KCIC, in partnership with other organizations, provides training and capacity building to high potential, growth-oriented, emergent businesses and investors, and local banks. The Center helps build the competitiveness of companies by providing local technologies, information on market size and prices for various technologies, the competitive landscape, market intelligence, technical and business advisory on best practices, and policy advocacy.[130]

Resource mobilization and market formation: KCIC has devised different funding mechanisms to address the financial needs of green projects (see Section 0). To develop and utilize human resources, the Center taps into diverse and complementary skill sets of various organizations, including government bodies, consulting firms, academic institutions, and civil society.

For market formation, in addition to strategies focussing on generating funds and addressing the needs of demand-supply dynamics, KCIC adopts a risk management approach. The Center focuses on managing both strategic and operational risks faced by its clients across various stages of the innovation cycle. The Center adopted a Risk Management Policy in 2017.[131] In specific terms, KCIC addresses:

- Investment risks through ESFM, bridging the valley of death;
- Reputational risk, undertaking trust-building between networks, actors, investors, and donors;
- Political risk, conducting policy advocacy with the government and international donors; and
- The non-availability of resources, including financial, human resources by creating appropriate networks.

These factors, in conjunction, support market formation for clean technologies.

Legitimation: To generate credibility and legitimacy for its activities, KCIC undertakes intensive stakeholder engagement with potential partners and beneficiaries while firming up the design and focus areas. Although the Center does not engage in political activities directly, it maintains good relations with the government, regulatory agencies, and other key stakeholders to facilitate the development of policies supporting technology adoption, coordinate and broker technology transfer and collaborative R&D, and international networking activities.[132] In addition, KCIC performs due diligence on its prospective clients, investors, and collaborators before making any investment or partnership decisions.[133] It also carries out client satisfaction surveys to assess its achievements and shortcomings. KCIC is also highly conscious of its reputation concerning international partners and donors, as negative perceptions may impede the uptake and performance of projects. The Center participates in international networking events/activities to increase the visibility of KCIC and associated innovators and green entrepreneurs,

[129] https://www.msn.com/en-xl/money/topstories/sustainable-commercial-forestry-that-grows-income/ar-AANe7wp?ocid=BingNewsSearch

[130] *InfoDev. 2016. Climate Technology Program In Brief-Number 2. The Kenya Climate Innovation Center - How it Operates and Lessons for Clean Technology Incubation. https://www.infodev.org/infodev-files/inbrief_no.2_kcic_0.pdf (accessed on May 5, 2022)*

[131] World Bank. 2018a. Kenya Climate Innovation Center Company Report and Financial Statements for the Year Ended 30 June 2018. https://documents1.worldbank.org/curated/en/339371548740230173/pdf/KCIC-FS-2018.pdf

[132] InfoDev. 2016.

[133] World Bank. (2018b). Kenya Climate Innovation Center Company Report and Financial Statements for the Year Ended 30 June 2018. https://documents1.worldbank.org/curated/en/339371548740230173/pdf/KCIC-FS-2018.pdf

and climate technology in general. Another critical factor that has enhanced the credibility of KCIC is the fact that the Center is in its third funding cycle.[134]

Development of positive externalities: The above discussions highlight how KCIC promotes the creation of an enabling and complementary political, financial, and technological infrastructure by working in association with government agencies, funding organizations, technology providers, etc. This not only helps KCIC's clients but also facilitates the development of an overall enabling environment for the innovation and implementation of clean technologies. In the process, the activities of the Center generate jobs, develop skilled human resources, and create physical infrastructure for future projects.

Table 7 presents the structure-function coupled analysis of KCIC.

Table 7: Structure-Function Coupled Analysis of KCIC

Function		Structural element	KCIC's Interventions
F1	Knowledge development and diffusion	Actors	• Training, capacity building, mentorship, customized guidance to promising, emergent projects/entrepreneurs • Provides market intelligence, business advisory to the entrepreneurs • R&D collaborations, research funding for innovation, clean technology development and diffusion • Improves fundraising capabilities of the clients • Pilots and demonstrations of new/innovative technologies (e.g., new rice varieties, etc.)
		Institutions	• Acting as an interface between companies and government agencies, facilitating the creation of complementary policy and regulatory setting to promote research, technology development, collaborations for knowledge development (e.g., quality standards, taxation, etc.)
		Inter-actions	• International and local collaborations, networking events, conferences, etc. to promote dissemination of knowledge and peer to peer learning
		Infra-structure	• Facilitates physical infrastructure for research and research demonstrations
F2	Entrepreneurial experimentation	Actors	• Innovative engagement/business models/funding mechanisms for different stakeholders • Livelihood generation for women, youth, etc.
		Institutions	• Acting as an interface between companies and government agencies, facilitating the creation of complementary policy and regulatory setting to promote innovative business models, funding mechanisms (e.g., quality standards, taxation, etc.)
		Inter-actions	• Facilitates interactions between relevant actors to promote uptake and implementation of green business projects
		Infra-structure	• Facilitates physical infrastructure for business implementation and actor engagements
F3	Market formation	Actors	• Funds (or generates funds) for green projects, developing the market supply side • Creates awareness about the merits of employing green technologies, developing the market demand side • Risk management to encourage participation by actors • Capacity building of actors to engage in the market • Livelihood generation, leading to the creation of demand • Awareness building, pilot projects to create demand for green projects/ products
		Institutions	• Acting as an interface between companies and government agencies, facilitating the creation of complementary policy and regulatory setting to innovative business models, funding mechanisms (e.g., quality standards, taxation, etc.) • Undertakes risk management (reputational risk, funding risk, political risk, etc.) for implementation of market processes
		Inter-actions	• Facilitating interactions between relevant actors to promote uptake and implementation of green business projects
		Infra-structure	• Creates supporting market infrastructure by developing funding mechanisms, skill trainings, allocation of physical space (office, networking hubs, etc.)
F4	Influence on the direction of search	Actors	• Recognition of priority sectors for support and funding by KCIC influences the selection of sectors/project categories by the green entrepreneurs
		Institutions	• KCIC supports/funds clients whose businesses/innovations are aligned with the country's overall policy goals • Facilitates creation of an enabling policy setting for RD&D on green projects

[134] Kiraka, 2021

Function		Structural element	KCIC's Interventions
		Inter-actions	• Facilitating interactions between business peer, funders and recipients, etc. to guide the direction of research, learn from global and local best practices, etc.
		Infra-structure	• Creation/provision of space and facilities for research, tie-ups with research organizations, universities, etc.
F5	Resource mobili-zation	Actors	• Mobilizes/generates funds for projects/actors by offering different business models/funding models and management of risks across the innovation cycle • Builds capacities of actors to raise funds
		Institutions	• Engages with the government to facilitate funding and implementation of projects (e.g., taxation, funding collaborations, etc.)
		Inter-actions	• Works as interface between potential funders and project implementers, facilitates delivery of funding
		Infra-structure	• Provides space and setting for engagements/interactions for generation of funds
F6	Legitimation	Actors	• Conducts due diligence on clients, investors, collaborators • Conducts satisfaction surveys to assess shortcomings, failures, etc.
		Institutions	• Acts as the official implementing agency of the Promote Climate Technologies and Innovation initiative under the Kenya Vision 2030 • Engaged in mainstreaming SDGs and climate change in the country
		Inter-actions	• Enhances the credibility of the project/process by mediating discussions between collaborators, funders, etc.
		Infra-structure	N.A.
F7	Development of positive externa-lities	Actors	• Creates a pool of skilled technicians to operate and maintain green projects • Builds capacities of actors to implement projects, fundraise, negotiate with collaborators, procure technologies, etc.
		Institutions	• Acts as an interface between companies and government agencies, collaborating with the government to introduce policy and regulatory changes for the market penetration of clean technologies
		Inter-actions	• Assists businesses to source funding from international, local banks and venture capitalists • Created and strengthened the green business value chains by enhancing network impacts
		Infra-structure	• Creates the knowledge infrastructure by bringing in research organizations, universities, domain experts, etc. as collaborators/mentors in the project • Creates the financial infrastructure by bringing in funding organizations (international, local), venture capitalists, etc. • Helps businesses access space, facilities, equipment, etc. for setting up office, networking hubs, etc. • Enhanced the value chains, business networks

3.2.6. Role of KCIC's initiatives in Kenya's NDC

In line with the country's sustainable development agenda and its national circumstances, Kenya's National Climate Change Action Plan (NCCAP) 2018-2022 identified critical sectors for mitigation and adaptation to achieve its NDC targets.[135] For GHG mitigation, the priority sectors include energy, agriculture, forestry, industry, transport, and waste. Water, agriculture, land use, forestry, energy, health, and infrastructure have been identified as the most crucial sectors for adaptation-related interventions. So KCIC's working areas significantly overlap with the priority sectors identified by the NCCAP in line with the country's mitigation and adaptation needs.

The NCCAP recognizes KCIC as one of the relevant institutions to implement the activities outlined under the plan. The Center's interventions have a direct role in delivering Kenya's NDC. KCIC is helping the country align its long-term development vision with the strategies to address climate change issues at appropriate levels (individual/enterprise, value-chain, and network levels). The Center is building actor capabilities, promoting green innovation across sectors, mobilizing climate finance, enthusing the private sector to engage in green projects, creating livelihood options, and supporting policy implementation. KCIC, in association with other organizations, is undertaking initiatives to generate climate finance from the local private

[135] Government of Kenya (2018). National Climate Change Action Plan (Kenya): 2018-2022. Nairobi: Ministry of Environment and Forestry. https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2018/10/8737.pdf

sector.[136] Kenya expects to source 87% of its climate finance needs from international support and the remaining from local actors.[137] As such, the activities of KCIC will contribute to achieving the NDC.

3.2.7. Key success factors and lessons learned

Lessons that can be drawn from KCIC's experience can be summarized as follows:

Organizations need to evolve and diversify with time to achieve their ultimate goals: Although initiated through external support, CICs are designed to function as ecosystem support providers and are expected to evolve, expand and diversify through learning-by-doing and eventually develop into self-sustaining, autonomous enterprises. KCIC is a successful example of this. The Center started as a consortium entirely funded by international actors, but as the Kenyan innovation system matured and KCIC's initiatives helped make green entrepreneurship popular in the country, the Center diversified correspondingly. The Center responded to the evolving needs of the Kenyan NSI by creating a specialized entity (KCIC Consulting) for providing hands-on mentorship and guidance to the emerging green businesses and a venture capital fund for addressing the investment needs of the entrepreneurs and enhancing the effectiveness of the impact investment. Moreover, the Center developed the capabilities to move beyond exclusively relying on foreign funding and generate internal or collaborative funding sources.

Collaborative, multi-actor partnerships crucial for effective climate action: KCIC demonstrates a robust consortium model involving different organizations from various sectors. The collaboration allows KCIC to leverage extensive and specialized local as well as international knowledge, skills, and experience to create an enabling environment for implementing clean technology innovation. KCIC also partners with specialized agencies for specific projects. The public-private, multi-actor partnership lends credibility to the organization and enhances the quality of the services provided by the Center to its clients, particularly sector-specific advisory and assistance.

Funding models need to be designed for the specific sector and phase of the innovation cycle: The financing needs of an innovation project depend on its sectoral focus, the project goals, the risk perception of the implementers, and the phase of the project in the overall innovation cycle. Accordingly, to customize the financial support to the innovation projects based on their specific requirements, KCIC has devized different and innovative funding mechanisms. The various funding tools help address not only the investment needs but also alleviate the technological, political, and reputational risks associated with the projects. Another critical lesson from KCIC's experience is the combination of incubation and accelerator funding mechanisms which help address the many of the funding needs of clean technology businesses.

Full integration with host country development objectives needed for effective outcomes: KCIC's strategic outlook, focus sectors, and specific activities are entirely in sync with the long-term sustainable development objectives and economic priorities of the host country. For instance, agriculture, the mainstay of the Kenyan economy, is one of the priority sectors of KCIC. Similarly, since Kenya is a water-stressed country, KCIC undertakes interventions to better manage and utilize water resources. This synergy not only lends credibility to the activities of the Center but also helps leverage the technical expertise and technological and financial resources received/generated from the external and local sources to achieve the country's overall goals. It also makes it easier for the government to recognize KCIC's contributions and facilitate its functioning.

Local actors' engagement at the design stage is crucial for effectiveness: In fact, this is the logic behind the setting up of tailor-made CICs in different countries. The approach and strategies of KCIC are tailored to address the gaps in the Kenyan NSI in relation to climate technology and focus on promoting sustainable development in the country. Emulation of KCIC's model in other country contexts may not generate similar results. Impressed by the success of the Center, its consortium model was emulated in Ethiopia, but this did not generate the intended results as the actors who were to implement the initiative did not participate in the design of the Center. Thus, besides building on the external support, it is crucial to leverage the expertise and experience of the local actors so as to come up with practical and compelling arrangements. This also lends legitimacy to the actions of the CIC, as evident in the case of KCIC.

Effective interaction among the local actors is vital for peer learning: Before engaging in any project, KCIC undertakes an intensive analysis of market barriers, issues in the value chain, and high-impact opportunities for innovation. For this purpose, rigorous consultations are conducted among the stakeholders, domain experts, regulators, etc. The business model designed as a result is not only crucial for generating impacts on the ground. It also results in peer-to-peer interactions that help build collaborations, generate climate finance, disseminate business ideas, business models, best practices, etc. The enterprises learn the most when they interact with their peers and similar industries at comparable stages of business development.

Need for effective networking between the CICs: Although CICs ought to follow a tailored approach, interaction among the different CICs is crucial for sharing best practices, forging partnerships, and drawing lessons from other countries' experiences.

[136] KCIC. https://www.kcicgroup.org/the-4c-kenya-sustainability-conference/ (accessed on May 5, 2022)
[137] Government of Kenya. (December, 2020). Kenya's first NDC (Updated Version). Submission of Kenya's Updated NDC 24th December 2020. https://unfccc.int/sites/default/files/NDC/2022-06/Kenya%27s%20First%20%20NDC%20%28updated%20version%29.pdf

A peer-learning event was organized in 2019 between the representatives of CICs from Bangladesh, the Caribbean, Egypt, and Ghana.[138] The closed group interaction between the CICs helped build solidarity between the participants and facilitated exchange of learnings regarding challenges to innovation and their solution processes. However, such interactions between the CICs are not a regular phenomenon. There is as yet unused potential for interactive learning between CICs.

CICs represent an example of an international collaborative initiative to leverage global capabilities to address local climate needs. It is not only about collaborations between developed and developing countries. It also aims at generating networks and partnerships between developing countries or the various CICs to bolster climate-relevant innovations.[139] Effective networking between the CICs could foster exchange of learnings, practices, and technologies and also expedite and scale up the deployment of clean, climate-relevant technologies.

International institutions and collaborations can help build local institutions for effective climate action: The success of KCIC demonstrates the complementary role of international support in building local capabilities for climate-relevant technology innovation. Moreover, it also shows that collaborations, interactions, and capacity-building efforts should not be limited to government-to-government exchanges. The international facilitation process should also engage local businesses and other relevant stakeholders for effective and long-term outcomes. KCIC's experience illustrates that international institutions (including multilateral development organizations) can help in three main ways. First, they can foster incubation and acceleration of technology; second, they can serve as an interface between the local actors and potential funding and technological resources; third, they can stimulate policy and market actions at the local level to create an enabling ecosystem for climate action. Where local actors lack the capability or the understanding to design effective strategies, international support can help identify the missing links in the NSI, design customized strategies, etc. In the process, the international actors can provide funding, technical and policy support, after which the local actors can operate independently.

3.2.8. Good practices for potential replication

The above lessons learned lead to the identification of the following good practices that might be replicable in other countries:

- Use international collaborations to develop local capabilities and resources: International partnerships and exchanges can be used to develop local technological, financial, political, and human resources such that reliance on international support can be brought down over time. Local actions should be aimed at using international support to create an enabling ecosystem for climate action in the long term and not be limited by a project-based mode of operation.
- Evolve and diversify through learning-by-doing: International funding and guidance should be used to kick-start an initiative. However, organizations should develop their capabilities and expand their intervention areas to become independent and effective entities with sustained relevance in response to the evolving characteristics of the local context.
- Design innovative, customized and flexible funding frameworks: Device funding models to suit the stage, scope, and risk perception of the innovators/firms. Complement the funding schemes with enabling policy and financial regimes for effective and sustained outcomes.
- Focus on market creation for climate technologies: For a mature and effective ecosystem for green entrepreneurship, policies, market structures, and actor capabilities should be directed towards creating sustained demand and supply dynamics for clean technologies.
- Engage both public and private sectors: Ensure the participation of diverse stakeholders to address the complexities and uncertainties associated with the innovation processes. This will also help in tapping into the different capabilities and skill sets of various actors.
- Integrate the goals of climate initiatives with the local policy goals and socio-economic priorities: Synergies with local objectives will help in enhanced participation by stakeholders and minimize risk perceptions. This includes issues such as gender parity, employment for youth, etc.

3.3. Case: Disaster Risk Reduction in Haiti

Country	Haiti	**Focus**	Adaptation
Scope	Country/disaster risk reduction in all sectors	**Key innovation system functions**	F1 Knowledge development and diffusion F4 Guidance of the search F5 Resource mobilization F6 Legitimation
Approach	Top-down and bottom-up	**Starting year**	2001

[138] CBIN sponsored a weeklong learning event for CICs in February–March 2019. Staff from four CICs—Bangladesh, the Caribbean, Egypt, and Ghana—convened in Ghana to learn about each centre's programme offerings and share best practices to improve operations. https://www.infodev.org/sites/default/files/ctp-scm_report_2019.pdf

[139] Sagar, A. D., Bremner, C., & Grubb, M. (2009, November). Climate Innovation Centres: A partnership approach to meeting energy and climate challenges. In Natural Resources Forum (Vol. 33, No. 4, pp. 274-284). Oxford, UK: Blackwell Publishing Ltd.

3.3.1. Introduction of the initiative

This case study will look at Haiti, a small island developing state (SIDS) in the Caribbean highly vulnerable to the impacts of climate change, and how it aims to reduce the risks associated with natural disasters. Haiti has been hit by many natural disasters throughout its past. From 1900 to 2010, the country was hit by 59 natural disasters, including cyclones, tropical storms, heavy flooding, droughts, and earthquakes.[140] It is one of the world's most affected countries in terms of economic losses from natural disasters, amounting to 17.5% of GDP over the past 20 years.[141]

The 2010 earthquake alone resulted in the loss of about 230,000 lives, the displacement of two million people[142] and hampered the country's development: damages amounted to 120% of Haiti's GDP, with the country falling from ranking 145th in the UN Human Development Index (HDI) just before the disaster to 168th in 2013.[143] The earthquake also undermined human capital and infrastructure within government: up to 20% of federal employees were killed or injured and around 25% of public buildings were devastated according to estimates.[144] Damages from Hurricane Matthew in 2016 cost around 33% of Haiti's GDP, pushing many of the country's residents further into poverty.[145]

Since 2001, there have been multiple measures to strengthen the country's ability to anticipate, face and resist natural disasters and to recover from the impacts in their aftermath. Haiti's economy heavily relies on primary sectors (agriculture, forestry and fishing), which are highly vulnerable to the impacts of climatic events.[146] With the frequency and scale of these events expected to increase with climate change, successful measures to reduce the risks of natural disasters become even more important. Understanding the effectiveness of these measures and the lessons that can be learned from them is crucial.

Disaster risk reduction (DRR) involves a systemic approach to management in order to limit the loss and damage from natural disasters. It aims to avoid, mitigate, or transfer the adverse effects of risks through prevention, preparedness and response activities.[147] It is a combination of political and administrative policies and activities, involving various actors and technologies as elaborated below.[148]

Text Box 1: Factors influencing vulnerability to natural disasters

Vulnerability to natural disasters is complex. It is determined not only by the geographical (and meteorological) situation. It also involves social, anthropological, economic, environmental, technical and engineering factors that influence a group's ability to anticipate, face and resist a natural disaster and to recover from its impacts. Risk exposure to natural disasters is hence a combination of vulnerability factors, including the (in)ability to adapt, and the characteristics of the natural disaster itself (cyclones, flooding, earthquakes, etc.), and the chance of occurrence.[149]

There are different factors that increase vulnerability to natural disasters.[150]

- Deep causes affect the allocation and distribution of resources among population groups. This includes economic, demographic and political processes, as well as legal institutions.
- Dynamic pressures: these are processes that transform the deep causes into conditions that are temporally and spatially dangerous. These include the lack of local institutions, capabilities, investments, local markets, press freedom, ethical standards.
- Dangerous conditions: these regard the specific forms in which the vulnerability of a population is manifested. These include for instance placements in dangerous zones, lack of building codes, lack of financing for more resistant housing, among others.

[140] Joseph (2010). Recurrence des catastrophes en Haïti: reflexion sur leurs causes et sur la gestion des risques de catastrophe. University of Geneva, Switzerland.
[141] Reliefweb, 2021, Haiti approves a new Risk and Disaster Management Plan, https://reliefweb.int/report/haiti/haiti-approves-new-risk-and-disaster-management-plan
[142] International Federation of Red Cross and Red Crescent Societies (IFRC) (2015). How law and regulation support disaster risk reduction: Haiti case-study report. Available at https://disasterlaw.ifrc.org/sites/default/files/media/disaster_law/2020-09/HAITI%20DRR%20Report.pdf
[143] International Federation of Red Cross and Red Crescent Societies (IFRC) (2015).
[144] International Federation of Red Cross and Red Crescent Societies (IFRC) (2015).
[145] Green Climate Fund (2019) Readiness and Preparatory Support Proposal for Republic of Haiti. Adaptation planning. Available at https://www.greenclimate.fund/document/adaptation-planning-support-haiti-through-undp
[146] Green Climate Fund (2019).
[147] Joseph (2010)
[148] Lettieri et al (2009). « Disaster management: findings from a systemic view » in Disaster Prevention and Management, Vol. 18, No. 2, Emerald Group Publishing Limited.
[149] Wisner et al (2004). «At risk, second edition: Natural hazards, people's vulnerability and disasters ». Routledge, London and New York.
[150] Wisner et al (2004).

From an NSI perspective, there are several structural elements that can influence the vulnerability of a population. Weak institutions may not provide strong enough regulations for building codes and settlements, or clear guidance for acting when facing a disaster. Lower actor capabilities regarding access to finance and knowledge may affect their ability to prepare for a disaster, for instance to build safer homes and to know how to react in different situations. The ability to cope during a natural disaster, for instance to organize rescue activities and humanitarian support, requires communication between actors. Here, weak networks between actors are expected to pose a challenge. Lack of reliable and disaster-resistant infrastructure, such as telecommunication networks and roads also influence the ability of a population to prepare and respond to a disaster. Strengthening functions of an NIS can help a country overcome important systemic issues related to disaster risk reduction, for instance by increasing knowledge development and sharing about risk exposure and management of natural disasters, mobilizing finance for resilient infrastructure, and creation of legitimacy by establishing guidelines and protocols.

3.3.2. Legislative framework

Until 1997, actions related to natural disasters in Haiti dealt mainly with disaster response, with little focus on preparedness.[151] After hurricane Georges in 1998 that begun to change. Prevention and risk management increasingly received more attention, including from international partners providing support in the aftermath of disasters.[152] The Government of Haiti started to prepare the first national plan for disaster risk management, called "Plan National de Gestion des Risques et des Désastres (PNGDR)".[153] The PNGDR was ready in 2001, raising disaster risk management to the highest priority.[154] The PNGDR has two main objectives:

- To address the factors that increase vulnerabilities and risk in order to reduce the possibility of a disaster occurring.[155] At the time, there was an understanding that managing the country's vulnerability and risk to natural disasters was a fundamental requirement to achieve sustainable development and fight poverty.[156]
- To strengthen the capabilities of actors at all levels – central, departmental, communal and local – to respond to needs in the event of a disaster. [157]

The PNGRD created the National System for Disaster Risk Management (Système National de Gestion des Risques et des Désastres - SNGRD) as the main coordination mechanism for disaster risk management. The SNGRD includes actors related to all different aspects of the prevention and mitigation of, and response to, disasters, ranging from the public sector to civil society, including the private sector, NGOs, international donors and other actors. This created a network with multiple levels of governance to allow for the management of disaster risks in a more decentralized way.[158] In 2004, the Government of Haiti, with support from the UNDP, used the PNGDR to prepare a national report on the prevention of natural disasters in the context of the 2005 World Conference on Disaster Reduction.[159] Later, the impacts of the 2010 earthquake conferred disaster-risk reduction and disaster-risk management much greater national prominence.[160]

The National Risk and Disaster Management Plan 2019-2030 was adopted in 2021. Four key frameworks were used in its elaboration.[161]

- The strategic development plan of Haiti (PSDH);
- Sectoral policies and plans;
- The regional strategy for global disaster risk management under the Caribbean Disaster Emergency Management Agency (CDEMA); and

[151] Joseph (2010).
[152] Joseph (2010).
[153] Republique d'Haiti (2001). Plan National de Gestion des Risques et des désastres. Available at https://www.preventionweb.net/files/29734_plannationaldegestionrisquesetdesas.pdf
[154] République de Haiti (2019). Plan national de gestion des risques de désastre 2019 – 2030. https://www.preventionweb.net/files/72907_plannationaldegestiondesrisquesdeds.pdf
[155] Joseph (2010)
[156] République de Haiti (2019).
[157] Joseph (2010)
[158] Joseph (2010).
[159] Joseph (2010)
[160] International Federation of Red Cross and Red Crescent Societies (IFRC) (2015).
[161] Reliefweb, 2021

- The Sendai Framework for Disaster Risk Reduction.[162]

3.3.3. The Haiti NSI: Actors and Institutions, and their Drivers, and Gaps

A low HDI often correlates to a weak NSI, increasing vulnerability to risks of natural disasters due to difficulties in terms of availability of financial resources, poor housing conditions, and access to education and health.[163,164] In 2000, Haiti had a Human Development Index (HDI) of 0.442, with mean years of schooling of only 3.8 years. In 2019, the country's HDI had improved to 0.510, but Haiti still ranks 170th out of 189 countries, being included in the "low human development category" according to UNDP.[165] A weak educational system, together with a lack of learning from previous events, led to insufficient knowledge among the Haitian population about the risks being faced. Lack of access to finance, as well as insufficient knowledge (e.g. about building codes) among the general population, meant that people could not sufficiently implement measures to limit the damage (e.g. families could not build more resilient homes).[166,167]

There are also factors that affect the ability of public institutions to prepare for and manage risks associated with natural disasters. The country has experienced political instability, including a conflict in 2004 which led to the deployment of a UN Peace Mission in the country. Moreover, a historical centralization of the administration and services around the capital Port-au-Prince has led to people living in vulnerable conditions in urban slums, while undermining the public administration's ability to provide support and services to the rural population in the country's interior.[168]

Several non-state actors engaging in disaster risk reduction and relief activities are operating in the country (UN agencies, bilateral agencies, NGOs), often increasing their presence in the aftermath of a natural disaster. This increases the need for effective coordination. Coordinating support during and after a disaster becomes challenging in the absence of established harmonization tools, such as protocols for rescue and relief operations and clear communication structures. It increases the risk of duplication of actions, leading to an inefficient allocation of scarce resources, and can lead to transaction costs for actors, e.g. because of duplicate reporting needs.[169]

Infrastructural issues increasing the country's vulnerability include the fact that all main cities and electrical cables and gas/fuel storage facilities are built on the coast, which are at risk of flooding, exposing residents to both direct flood risks as well as the safety risks of flooded wiring.[170] In addition, structural engineers are mostly involved in the design of high-rise buildings, being more financially attractive. This leaves the design and construction of low-rise buildings to small-scale contractors, who do not always have the technical knowledge for building more resilient infrastructure.[171] High rates of deforestation, including for acquiring biomass for cooking also increases risk exposure to certain natural disasters.

To reduce vulnerability and increase the country's ability to anticipate, face and resist natural disasters and to recover from their impact several of these gaps were covered by the PNGRD objectives:

- Institutional actions needed to be strengthened around a long-term vision for disaster risk reduction, in coordination between the Haitian government, other national actors, and international donors.

[162] The Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan in 2015, aiming to 'achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years.' It outlines four priorities "to prevent new and reduce existing disaster risks: (i) Understanding disaster risk; (ii) Strengthening disaster risk governance to manage disaster risk; (iii) Investing in disaster reduction for resilience and; (iv) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction." Source: UNDRRR, 2005, Sendai Framework for Disaster Risk Reduction 2015-2030, https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

[163] Joseph (2010)

[164] World Bank's Climate Risk and Adaptation Country Profile (2011)

[165] UNDP (2020) The Next Frontier: Human Development and the Anthropocene. Briefing note for countries on the 2020 Human Development Report. Haiti. http://hdr.undp.org/sites/default/files/Country-Profiles/HTI.pdf

[166] Joseph (2010)

[167] Schacher (2014) Disaster-Risk Reduction through the Training of Masons and Public Information Campaigns: Experience of SDC's "Competence Centre for Reconstruction" in Haiti. In John F. Shroder, Max Wyss, Hazards and Disasters Series, Earthquake Hazard, Risk and Disasters https://doi.org/10.1016/B978-0-12-394848-9.00003-1

[168] Joseph (2010)

[169] De Silva and Prustalis (2010). The Sahana Free and Open-Source Disaster Management System in Haiti. In: ICT for Disaster Risk Reduction. Chapter 2. Incheon City, Republic of Korea: United Nations APCICT-ESCAP

[170] Joseph (2010)

[171] Schacher (2014)

- A mechanism for valuing local participation and knowledge was required, based on the experience from the 2010 earthquake that local networks of neighbors were crucial for rescue operations.
- The creation of a system for knowledge development and knowledge sharing was another key point to increase awareness and capabilities to prevent and manage future disasters.
- A revision of the school curriculum was needed, in order to adapt knowledge production and learning to the local needs in relation to natural disasters.
- Standards and protocols had to be developed regarding all phases of risk management and response to natural disaster to facilitate action in the face of an event, as well as monitoring and evaluation processes.[172]

The Directorate for Civil Protection (DPC) of the Ministry of the Interior and Territorial Communities (MICT) is primarily in charge of risk and disaster management in Haiti. In 2019, a law was in discussion to provide more capacity and autonomy.[173] With the approval of the DRM Law in June 2020, DPC has become a General Directorate (GDPC) within the MICT.[174]

3.3.4. Description of the initiatives

The main aspects of the government's top-down approach as laid down in the PNGRD will be described below. However, several initiatives have been implemented by non-state actors like NGOs and international donors. While a review of all initiatives goes beyond the scope of this case study, two examples of such bottom-up interventions are also discussed below.

Government-led initiatives under the PNGRD framework

Creation of a network of local committees for disaster risk management: committees for disaster risk management were established at the local level, making sure that every town had its own committee, reducing dependence on centralized governance structures from Port-au-Prince. Moreover, this network created a common core curriculum for training in disaster risk preparedness and responses, conducted education and awareness raising activities among the population, and improved coordination. It also helped to create an emergency plan that established a mechanism for organizing interventions in the case of an event, including a coordination unit composed of at least three people, and guidelines for communication management in emergency settings.[175]

Implementation of platforms and mechanisms for institutional and intersectoral coordination, both at strategic and operational levels: the establishment of platforms such as the SNGRD, the International Cooperation Support Group (GACI), the NGO Forum, thematic committees on DRR aspects, as well as the UNDP Civil Society Advisory Committee, have helped to promote the development, systematization and standardization of tools and practices, such as plans, protocols and procedures. The establishment of Emergency Operations Centers (EOC) by the Directorate of Civil Protection (DPC) of the Ministry of the Interior, created a framework to provide coordination during emergency situations.[176] EOCs allow local emergency response personnel to collect and analyze reported information, make decisions, and manage Haiti's collective response to natural disasters.[177] Various EOCs were established over the years in different locations, and in 2021 a national EOC (COUN) was established. The EOCs publish regular reports.[178]

Development of plans, protocols, procedures, and other management tools: as established by the PNGRD from 2001, several guidelines were developed, including:

- A disaster response plan (2001, updated in 2009);
- A manual for the organization and operation of the EOCs (2006, revized in 2017); and
- A guide for management of evacuation shelters (2013).

[172] Joseph (2010)
[173] UNDRR, 2019, Haiti works together with the United Nations Office for Disaster Risk Reduction - Regional Office for the Americas and the Caribbean to strengthen its presence and commitments into Caribbean risk reduction initiatives, https://www.eird.org/americas/news/haiti-works-together-with-the-united-nations-office-for-disaster-risk-reduction.html#.Ys2aEHZByUkUn
[174] World Bank GFDRR, 2021, Building Physical, Fiscal and Inclusive Resilience in Haiti, https://www.gfdrr.org/en/building-physical-fiscal-and-inclusive-resilience-haiti
[175] République de Haiti (2019).
[176] République de Haiti (2019).
[177] Reliefweb, 2012, Ground-breaking Ceremony for Disaster Response Facilities in Miragoane, https://reliefweb.int/report/haiti/ground-breaking-ceremony-disaster-response-facilities-miragoane#:~:text=The%20Emergency%20Operations%20Center%20will,provide%20relief%20to%20affected%20populations.
[178] Reliefweb, 2021, Haiti Earthquake ETC Situation Report #2 Reporting period 20/08/2021 to 26/08/2021, https://reliefweb.int/report/haiti/haiti-earthquake-etc-situation-report-2-reporting-period-20082021-26082021

In addition, several action and contingency plans were developed and revized annually.[179]

Information management: improving information management was a priority in the PNGRD both during an emergency and in normal times. Haiti put in place mechanisms for the collection of data on disaster risks, vulnerabilities and impacts, including the creation of a national database. The country also established information management cells and trained and hired personnel for handling and analyzing the data, both in the field and in the EOCs.[180] DPC established a national early warning system (EWS) under the PNGRD and procedures for risk mapping, also with the support from international partners to implement effective EWS in many communities.[181]

Training and communication activities: the PNGRD 2001 led to the creation of several new courses covering the fundamental principles in DRR such as the understanding of risks of, preparedness for and potential responses to natural disasters. This included trainings and information sharing (amongst others about alert systems, rapid assessment of damage and needs, management of evacuation shelters, management of emergency operation centers, simulation exercises). There were also initiatives to increase awareness on DRR issues within formal educational programs, including at university level via, for instance, the creation of a post-graduate programme. Some of these initiatives were established in collaboration with foreign universities such as the Swiss University of Geneva and the French University of Nice.[182]

Moreover, the Thematic Committee for Education and Public Awareness (CTESP) was created to provide coordination in awareness raising activities. This committee brings together the main DRR stakeholders in support to DCP, aiming to improve public knowledge regarding main disaster risks and the best practices to reduce these risks to implement throughout all phases of a disaster. The Committee's activities aimed to increase not only the awareness about the possibility of, and risks associated with, natural disasters, but also to enable actors to act in the face of events and to anticipate and recover from impacts of such events. The targeted audience comprized individuals, families and local communities, including local leaders and the media. CTESP also carried out the validation, harmonization and systematization of hundreds of audiovisual tools and general activities for education an awareness raising. [183]

Regarding communication activities, the government carried out multiple efforts to inform the population, especially the most exposed and vulnerable groups, about disaster risk reduction and management, both on how to prevent disaster risk, and how to respond to a disaster as it happens. These efforts included communication campaigns by local volunteers and DPC, as well as the use of media campaigns, in newspapers, on television, but also using mobile communication and social media. These activities were carried out during emergencies and in normal times.[184]

Integration of DRR into strategic documents: disaster risk management and reduction were integrated as a cross-cutting issue into government planning, being directly associated with general environmental, poverty reduction and social development policies. Moreover, the Ministry for Planning and External Cooperation (MPCE) has carried out efforts to include DRR as a conditionality for all international cooperation programs and projects, in as similar way to what is currently done for the requirement to include environmental impact assessment studies.[185]

Establishment of public financial instruments: A law from 16 September 1966 had created a public fund for emergency situations, by collecting 1% of salaries, initially from public employees, but later also from the private sector.[186] In addition, the government established dedicated budget lines for emergency response and preparedness. Haiti had multiple risk-financing instruments in place, supported by the World Bank and partners such as the European Union, benefitting from funding innovations in disaster-risk financing.

Haiti has subscribed to the Caribbean Catastrophe Risk Insurance Facility (CCRIF), a regional insurance mechanism which makes insurance funds available rapidly after a natural disaster strikes.[187] The CCRIF provided US$ 7.7 billion to Haiti after the 2010

[179] Such as plans for hydrometeorological and seismic contingencies and procedures for meteorological monitoring developed by the Hydrometeorological Unit of Haiti (UHM). Source: République de Haïti (2019)
République de Haiti (2019).
[180] République de Haiti (2019).
[181] IFRC (2015)
[182] République de Haiti (2019).
[183] République de Haiti (2019).
[184] République de Haiti (2019).
[185] République de Haiti (2019).
[186] It is as yet unclear whether this fund still exists.
[187] CCRIF SPC was established in 2007 as the first multi-country risk pool in the world with technical support from Japan. CCRIF SPC is capitalized by premiums paid by its member countries and funds from various donors, such as Canada, the EU, Germany, Ireland, and Mexico, allowing it to sustainably provide disaster-risk financing in the form of insurance to Central American and Caribbean countries.

earthquake, accounting for around half of all funding the country received in the first 10 weeks after the event.[188] The subscription to CCRIF SPC reflects shift the focus from reactive post-disaster response to a more proactive approach focusing on prevention and preparedness.

Haiti has other mechanisms in place, such as the World Bank's Contingency Emergency Response Component (CERC), which allows funds to be reallocated from existing projects to address emergency response needs. The Bank is also working with the Government of Haiti and other development partners on a comprehensive needs-assessment and recovery plan. This will be used to mobilize funding from the World Bank and partners for a resilient and inclusive recovery and reconstruction in Haiti.[189]

Civil society led initiatives after the 2010 earthquake

Following the 2010 earthquake some bottom-up initiatives to improve DRR in Haiti were led by NGOs, volunteers and international donors. Two relatively well-documented examples are given below.

Knowledge for resilient reconstruction: After the 2010 earthquake, the Swedish Agency for Development and Cooperation carried (SADC) out a project to re-build a school and offer training for the local population at the periphery of the earthquake-affected area. SADC explicitly focused on the rural areas of Haiti, where the involvement of structural engineers in construction projects is rather low, leading to less-resilient buildings. The aim was to increase infrastructure resilience during the reconstruction phase and augment local capacities. They provided support in developing and disseminating appropriate building techniques and improving general public awareness of earthquake and hurricane-resistant building methods. [190]

Sahana software for information management during emergency situations: an important challenge during emergency situations regards data collection and management during the response phase to help actors identify the scale of the disaster and coordinate action. This can be especially difficult since infrastructure, such as telecommunication and electricity, is often damaged in the aftermath of a disaster, and remote areas can be more difficult to reach. Additionally, often only limited bandwidth is available, as well as few hardware devices that can run applications. Human resources can be unfamiliar with software, with little time available for learning. In addition, with several organizations and volunteers coming in to help, coordination is crucial to avoid duplication and ensure scarce resources are allocated optimally. If the software used during disaster responses does not address these concerns, actors often go back to manual/offline sources, undermining information sharing and management during the response.[191]

The Sahana Free and Open-Source Disaster Management System was developed by volunteers from the ICT industry to help overcome the challenges created by large scale disasters. It was first deployed in Sri Lanka during the Indian Ocean Tsunami in 2004, but has since been deployed in other countries in the aftermath of natural disasters. It is designed to have the ability to adapt to the constrained environment ICT solutions face during disaster response. For instance, it facilitates the interoperability with existing systems, is bandwidth-efficient, has a quickly accessible interface and can run on low hardware specifications.[192]

Following the 2010 earthquake in Haiti, the Sahana Software Foundation and the Sahana community of volunteers responded with a big voluntary effort. They set up the Sahana Haiti 2010 Earthquake Disaster Response Portal, a live and active public website to help fill gaps in information management during the relief operations.[193] One of the ICT solutions under Sahana known as Sahana's Organization Registry (SOR) provided a searchable database that helped track organizations and offices working on the ground in Haiti on disaster relief, there location, who they were already helping and what assets and resources they had available. SOR became the main repository for contact details during the first weeks of the response. Organizations could self-register by email or report to their office locations.[194] Crowdsourcing of volunteers played an important role in mobilizing human capital for data collection and management, especially since the government capabilities were seriously

[188] République de Haiti (2019). pdf
[189] World Bank, 2021, Haiti's Path to Building Financial Resilience Against Disasters, https://blogs.worldbank.org/sustainablecities/haitis-path-building-financial-resilience-against-disasters
[190] Schacher (2014)
[191] De Silva and Prustalis (2010).
[192] De Silva and Prustalis (2010).
[193] De Silva and Prustalis (2010).
[194] De Silva and Prustalis (2010).

hampered after the disaster. Volunteers were assigned to assist with data entry into the SOR and to merge information from multiple existing sources.[195,196]+,[197]

The Sahana Software Foundation worked with the U.S. State Department and other actors on a project to process SMS text messages sent from Haitian citizens with requests for assistance. Messages were processed and put into a structured data format providing the sender's name, location and category of the message.[198] The software was also able to gather information from Twitter about affected or missing persons, as well as population needs, using a hashtag system. Sahana centralized the information in a way that all actors could see all requests, as well as which request had already been answered by whom. The repository system was later adapted to synchronize with the Hospital Management System for requests for assistance, resources, staff and medical supplies. It also supported the World Food Programme with identifying needs and planning the distribution of food supply.[199]

3.3.5. Assessment of the initiatives

Knowledge development and diffusion: There were several activities in Haiti that contributed to improve DRR knowledge development and diffusion. This includes top-down activities, such as the national database established to provide data on disaster risks, vulnerabilities and impacts, the creation of information management cells and training of personnel for handling and analyzing data under the PNGRD. Bottom-up, the response from the Sahana community via the establishment of the Sahana's Organization Registry also provided a searchable database to help coordinate action in relief operations, with volunteers playing a crucial role in collecting data and uploading it in the database.[200,201,202]

As a result, Haiti now has an openly accessible national database[203] that provides GIS and cartographic data about risks and hazards of river and coaster floods, water scarcity, cyclones, earthquakes and landslide.[204] Information comes from several organizations, including research institutes, government and development partners[205] and has been used by a wide range of actors involve in risk and disaster management, urban planning, agriculture and food security, environmental management, etc.[206] There is room for further improvement, according to the Green Climate Fund, through better integration of climate change-related risks and including data concerning the resilience of different population groups.[207] In addition to the database, Haiti has consolidated EWSs for flooding and hurricanes.[208]

Knowledge diffusion was also aided by educational and training activities under the PNGDR. The establishment of new university courses contributed to the integration of DRR into university curricula, and hence to increasing the overall technical capacities of graduates to handle disaster risk reduction issues in their professional life.[209] The International Federation of Red Cross and Red Crescent Societies (IFRC) observed in 2015 that some good practices can be identified in Haiti's educational policy, such as the fact that environmental education is a mandatory part of the curriculum offers the opportunity to incorporate DRR into the primary and secondary school activities. [210] However, it concluded that the actual inclusion of DRR in the national school curriculum – beyond universities - still had room for improvement. Bottom-up, NGOs have also been

[195] De Silva and Prustalis (2010).
[196] Depelteau (2013). L'usage et l'appropriation des communications mobiles textuelles par les acteurs de la réponse humanitaire du séisme du 12 janvier, 2010 en Haïti. Montreal, Canada: Université du Québec
[197] Kankanamge et al (2019) Can volunteer crowdsourcing reduce disaster risk? A systematic review of the literature. International Journal of Disaster Risk Reduction 35 (2019) 101097.
https://doi.org/10.1016/j.ijdrr.2019.101097
[198] e.g., an immediate lifesaving request, missing person report, etc.
[199] De Silva and Prustalis (2010).
[200] Kankanamge et al (2019)
[201] De Silva and Prustalis (2010).
[202] Depelteau (2013).
[203] https://haitidata.org/
[204] https://haitidata.org/
[205] Green Climate Fund (2019).
[206] https://haitidata.org/
[207] Such as information about gender, socio-environmental vulnerabilities and capacities (Green Climate Fund, 2019).
[208] IFRC (2015).
[209] République de Haïti (2019).
[210] IFRC (2015).

conducting activities to bring awareness of DRR into schools.[211] The project from SADC helped to spread technical knowledge of building codes among the rural population of Haiti, increasing their capabilities to build more resilient homes.[212]

IFRC considered that the structure developed for knowledge development and sharing in Haiti has been relatively effective, with MICT and DPC being able to coordinate a large number of actors at the national level[213]. CTESP contributed to public awareness activities, targeting all types of audiences, and using several communication channels, including the DPC local structures and the mass media[214]. These types of communication activities helped to overcome knowledge gaps among the population, for instance about how to proceed in the face of a disaster or how to be better prepared. IFRC concluded that the network of public awareness information has been generally effective and widespread, with "clearly a large amount of DRR and DRR-related training taking place", led by the DPC and other partners[215].

All these activities and actors contributed to strengthening knowledge development and knowledge sharing in DRR and DRR-related issues in Haiti. In 2019, the Government of Haiti stated that these measures led to significant progress in terms of coordination, public information and awareness, capacity building for intervention, and the development and diffusion of methods and technologies for the prevention, reduction of risks and response to natural disasters.[216] A report from the Green Climate Fund[217] states that the PNGRD and the SNGRD have strengthened national and decentralized institutions and civil society capacities to address disaster risk management. IFRC also concluded that these initiatives have led to the development of a relatively effective structure at all levels of government that supports coordination across several actors, from public stakeholders, to international donors, to the private sector.[218] In fact, IFRC highlights that Haiti's current annual preparations for the hurricane season are widely praised by those involved in the system.[219]

Entrepreneurial experimentation: The use of the Sahana Open-Source Software can be seen as a bottom-up entrepreneurial endeavor from the Sahana community and users such as volunteers and international donors. The experience with the Sahana software then contributed to other databases being created.

Influence on the direction of the search: Coordination among different actors helped to establish guidance and protocols on DRR and has influenced plans and protocols for DRR since then. For instance, the PNGRD 2019-2030, Haiti's most recent DRR policy plan, builds on past efforts under the 2001 PNGRD while sectoral laws now include DRR-related provisions. This way, the PNGRD helped to create "norms" regarding several DRR aspects in Haiti, for instance on how to communicate about the risks of a disaster, how to react in face of it, how to construct buildings, and so on. This was facilitated via the creation of networks including different types of actors (i.e., from ministries, to communities, local leaders, donors and international volunteers) at all levels: local, sectoral, national and transnational.

Resource mobilization: DRR and relief efforts in Haiti use support from multilateral and bilateral aid agencies, such as the World Food Programme, UNDP, the Green Climate Fund, SDAC and others.[220,221,222,223] The response to disasters in Haiti has also mobilized direct contributions from civil society, for instance via crowdsourcing,[224] the provision of open-source software such as Sahana,[225] as well as support from NGOs.

In 2015, IFRC concluded that Haiti remained chronically under-funded and over-dependent on external funding, with more than 50% of the government budget coming from international aid. They argued that this impacted the effectiveness of the national system for disaster risk management and that, for instance, DPC would not have been able to maintain its operations without international funding, notably from UNDP.[226] With the establishment of the National Bureau for Environmental Assessments in 2015, some private actors started carrying out environmental impact assessments, but climate-change and

[211] IFRC (2015).
[212] Schacher (2014)
[213] IFRC (2015).
[214] République de Haiti (2019).
[215] IFRC (2015).
[216] République de Haiti (2019)
[217] Green Climate Fund (2019)
[218] International Federation of Red Cross and Red Crescent Societies (IFRC) (2015).
[219] International Federation of Red Cross and Red Crescent Societies (IFRC) (2015).
[220] Green Climate Fund (2019)
[221] Schacher (2014).
[222] De Silva and Prustalis (2010).
[223] IFRC (2015)
[224] Depelteau (2013).
[225] De Silva and Prustalis (2010).
[226] IFRC (2015)

DRR-specific investments from the private sector still remained low in 2019.[227] Haiti has been receiving support from the Green Climate Fund to address this issue.[228] Establishing more independent and stable sources of finance remains a challenge to be addressed in order to ensure the long-term effectiveness of the Haiti's national DRR system.

Haiti has, with international support, made efforts to more away from disaster response financing to more strategic – and proactive - strategic disaster-risk financing (DRF), including the subscription to the insurance pool of CCRIF. DRF is important to increase the resilience of countries to natural disasters by establishing more predictable financial resources than international aid can provide. By planning ahead, countries can, for example, invest in shock-responsive safety net mechanisms, registries of beneficiaries, aid logistics, and pre-established national disaster funds, which all facilitate rapid assistance to the at-risk population in a reliable, predictable, and efficient way. Haiti is currently developing a comprehensive DRF strategy, in partnership with the EU's Caribbean Regional Resilience Building Facility, which will likely include instruments such as CCRIF SPC coverage, contingent credit lines, emergency funds, and coordinated budget reallocations.[229]

Legitimation: The PNGDR led to the development of several protocols and procedures for DRR. Importantly, this was done by taking actors and local capabilities into account. A clear example of good practice here is the implementation of the National Building Code, which includes provisions for the design of structures against wind and seismic risks.[230] The code is praised for adapting technical language to make it more understandable for the general Haitian population, at a layman level. Instead of simply setting out very technical requirements and mathematical calculations, it relies on the creative use of diagrams to ensure a larger share of Haitian can understand and apply the code.[231]

The PNGDR also led to the integration of DRR into strategic documents and national planning. Most of Haiti's sectoral laws contain DRR-relevant elements,[232] integrating climate change adaptation concerns into the country's disaster management plan[233] and aligning it with overall development objectives.[234] Nevertheless, in many areas the effectiveness of implementation and enforcement of these laws falls short due to funding and capacity constraints, especially at local levels.[235] DPC is subordinate to MITC, which can lead to a lack of legal certainty according to the IFRC (2015), undermining long-term planning.[236] It is unclear to which extent the new DRM law sufficiently addresses this issue.

Development of positive externalities: In 2019, Haiti's HDI had improved to 0.510 from 0.442 in 2000, in part due improving education and health indicators (with mean years of schooling increasing from 3.8 years to 5.6 years and life expectancy at birth from 57 to 64 years). DRR induced advances can have had a positive impact on such indicators. This can, however, not be substantiated at this point.

In summary, the measures undertaken for DRR in Haiti after 2001 have led to significant progress in strengthening functions of the country's NSI. They have also increased actors' capabilities, created and strengthened networks of actors and established important institutions. These were significant steps to increase Haiti's ability to anticipate, face and resist natural disasters and to recover from their impacts.

Nevertheless, challenges remain to be addressed, especially concerning long-term planning, financial stability and effective implementation and enforcement, due to funding and capacity constraints, especially at the local level. With the development of new international agreements such as the Sendai Framework for Disaster Risk Reduction and the Paris Agreement, a new PNGRD (2019-2030) was adopted. The impact of this is, however, not assessed in this study, due to its recent character. Nevertheless, its development emphasizes the need for continuous monitoring and evaluation to take stock of progress, identify gaps and new developments, and to readapt strategies, in order to ensure effective long-term planning.

[227] Green Climate Fund (2019).
[228] Green Climate Fund (2019).
[229] World Bank, 2021
[230] IFRC (2015)
[231] IFRC (2015)
[232] IFRC (2015)
[233] Green Climate Fund (2019)
[234] République de Haïti (2019)
[235] IFRC (2015)
[236] IFRC (2015)

Table 8: Summary of structural-function coupled analysis of the Haitian case.

Function		Structural element	Interventions
F1	Knowledge development and diffusion	Actors	• Communication campaigns by local volunteers and DPC, as well as the use of media campaigns, in newspapers, television, but also mobile communication and social media • The Thematic Committee for Education and Public Awareness (CTESP) provides coordination in awareness raising activities • Individuals, families and local communities, including local leaders and the media were targeted in awareness raising campaigns • Training for actors involved in data collection and management • Several organizations, including research institutes, government and development partners provide data and information to the national database
		Institutions	• New courses were established at university level • Decentralization efforts, through the empowerment of local committees and initiatives • Creation of sectoral committees for knowledge development and diffusion in certain areas
		Interactions	• Creation of a network of local committees for disaster risk management • Implementation of platforms and mechanisms for institutional/intersectoral coordination, both at strategic and operational levels
		Infra-structure	• Training for building more resilient infrastructure • Creation of national databases • Establishment of early warning systems
F2	Entrepre-neurial experi-mentation	Actors	• This function was fostered by several actors, for instance the government, but also local committees, volunteers and international donors
		Institutions	• The use of the Sahana Open-source software helped later with the creation of additional databases, helping to consolidate data management for DRR
		Interactions	• Interactions between networks of the Sahana Community, volunteers, donors and public organizations
		Infra-structure	• Use of Sahana Open-Source Software
F3	Market formation[1]	Actors	
		Institutions	
		Interactions	
		Infra-structure	
F4	Influence on direction of search	Actors	• The government established the SNGRD, a national system for coordination • Multiple actors contributed to improve coordination under several thematic committees
		Institutions	• Established guidance and protocols on DRR have influenced further plans, protocols and even sectoral laws, helping to integrate DRR into national planning
		Interactions	• Strengthened networks promoted interaction between different actors, e.g., between those implementing teaching, and governments and communities • These networks became reference points for the establishment of guidance and protocols for DRR in the country
		Infra-structure	• Plans, guidance, protocols and better information provision about geospatial data have contributed to influence the building of new infrastructure in Haiti, and to integrate more resilience techniques into building practices
F5	Resource mobilization	Actors	• Government funding • International and multilateral financial institutions • International donors such as bilateral and multilateral aid agencies • Volunteers and civil society (e.g., crowdfunding) • Caribbean Catastrophe Risk Insurance Facility (CCRIF)
		Institutions	• Public fund established by the law of 1966 • Dedicated budget lines for emergency response and preparedness. • Participation in regional insurance mechanisms • Preparation of a Disaster Reduction Finance strategy
		Interactions	• Coordination mechanisms via e.g., Sahana database on who is providing support for what, and what the needs are
		Infra-structure	• Mobilization of financial resources and human resources (volunteers) for reconstruction after natural disasters
F6	Legitimation	Actors	• Sectoral committees help with the development of standards and protocols
		Institutions	• Development of plans, protocols, procedures, • Integration of DRR into strategic documents

Function		Structural element	Interventions
		Interactions	• Protocols provided guidelines for interaction, clear structure for communication, etc., for preparing and in the face of a natural disaster
		Infra-structure	• Establishment of codes and protocols facilitated the building of more resilient infrastructure
F7	Develop-ment of positive externalities[1]	Actors	
		Institutions	
		Interactions	
		Infra-structure	

[1] Please note that grey cells mean that not enough information was available to suggest that the initiatives here discussed have significantly contributed to these functions. This however does not mean that they did not contribute in reality, see e.g. the discussion on potential contribution to the improvement of Haiti's HDI above.

3.3.6. Role of the initiatives in Haiti's NDC

The NDC[237] does not explicit mention the PNGRD as an overarching institutional framework contributing to climate change goals. The updated NDC, however, does mention the need for capability building and technology transfer for Haiti's contribution to climate change mitigation and adaptation, highlighting the importance of this process to be appropriately tailored to the national context and needs.[238] Moreover, it says that in line with its national policy for fighting climate change,[239] the emphasis should be on:

- Building capabilities of actors such as public servants, private sector and civil society on climate change;
- Involving universities in the training and research programs on climate change-related issues, including the update of the NDC;
- Improving government capacity through reforming legal and institutional frameworks and inter-institutional cooperation;
- Creating an educational, communication and awareness plan for the general public;
- Including climate change and sustainable development in school curricula starting from primary school.[240]

The new PNGRD (2019-2030) does not make a direct link to the country's NDC, but the it was developed in line with Haiti's strategic development plan (PSDH) and sectoral policies and plans. Therefore, given the contribution of past DRR initiatives to strengthening Haiti's NSI in those functions, leveraging the experience, networks and capabilities build for DRR is expected to support the adaptation goals in the NDC.

3.3.7. Key success factors and lessons learned

Haiti's experience with DRR provides some useful lessons learned:

Importance to take a systemic perspective: Vulnerability to natural disasters relates to multiple factors, hence disaster risk reduction requires a systemic approach. In order to have more resilient infrastructure in Haiti, techniques for more resilient buildings had to be developed. For this, new protocols had to be established to harmonize construction practices throughout the country and the university curriculum had to be revisited. Furthermore, for this new knowledge to become widely adopted by the Haitian society, these techniques and codes also had to be shared and communicated with a range of actors. For this, networks had to be strengthened. While the introduction of new technological hardware can support DRR efforts, for instance by providing more resilient construction materials, this will have only limited impact if knowledge – software – and institutions – orgware – are not also developed to support their uptake.

Need to include local knowledge and needs: In the face of a disaster, local communities are crucial in providing support, since communication and transportation networks are often down. Building the capacity of local communities to prevent and react in the face of a disaster is therefore crucial. Haiti undertook significant efforts to decentralize the administration and empower local communities in DRR. Training and information activities are also more effective when conducted in collaboration with local partners. This ensures that the training and information are better suited to local needs and knowledge, and that they

[237] République de Haïti (2022). Contribution Déterminée au niveau National de la République d'Haït. https://unfccc.int/sites/default/files/NDC/2022-06/CDN%20Revisee%20Haiti%202022.pdf
[238] République de Haiti (2022)
[239] Politique Nationale de lute contre les Changements Climatiques – PNCC
[240] République de Haïti (2022)

indeed reach the target audience.

The importance of coordination via networks: Strong networks are crucial to provide coordination and ensure effective disaster risk management and reduction. They help sharing and managing information about vulnerabilities of local populations while building capacity of local actors by facilitating access to knowledge. They support the coordination of actions and identification of needs, as well as the establishment of codes of conduct and best practices. Weak networks can significantly undermine a country's ability to anticipate, face and resist natural disasters and to recover from it impacts.

Combined top-down and bottom-up efforts can create synergies: Making use of efforts and infrastructure of bottom-up initiatives such as the Sahana community using the Sahana Open-Source Software to create the SOR increased the scope and effectiveness of Haiti's data management and sharing activities. The bottom-up Sahana activities contributed to other databases being created and increased the amount of data available for inclusion.

Importance of multi-stakeholder partnerships, including international collaboration: the Haiti case showed the importance of collaborating with a variety of actors, from local to national actors, and including volunteers and international development partners.

Systemic change requires time: Systemic change entails not only changes in technologies, educational programs and regulatory frameworks, but also a change in behavior. New collaborations need to be formed, knowledge needs to be put into practice, new routines need to be established. Actors need to collaborate with stakeholders they are not used to collaborate with. New practices under building codes need to be implemented in new construction projects. People need to learn new skills and integrate them into their practices. New data collection and reporting practices need to be incorporated into the routine of organizations. Experts conducting trainings need time to identify the needs from the local population and to incorporate feedback into future activities.

Importance for long-term planning and review: The case of Haiti highlights a need for continuous monitoring and evaluation to take stock of progress, identify gaps and new developments, and to readapt strategies, in order to ensure effective long-term planning.

3.3.8. Good practices for potential replication

The above lessons learned lead to the identification of the following good practices in the Haiti DRR case that might be replicable in other countries:

- *Focus beyond hardware innovation:* Technological hardware such as satellites can have an important contribution to DRR by helping with early warning systems. However, building capacity of local actors, creating the right communication channels for sharing knowledge and information, and establishing the right regulatory framework are crucial aspects of a DRR strategy.
- *Strengthen local capabilities, while ensuring coordination across different types of actors and levels:* Strengthening capabilities of local communities is crucial for effective DRR action. However, there is also a need for harmonization of curricula, protocols and information management mechanisms. Finding the right balance between bottom-up and top-down processes can be challenging, but can contribute to more effective strategies. Partnerships across a variety of actors can help build capacities and strengthen coordination across levels.
- *Plan according to longer time frames, while allowing monitoring, evaluation and review:* Since systemic change requires time, short-term planning (with too short time frames covering only a couple of years) will only be effective to a limiting degree in achieving objectives. It is therefore important to plan according to longer time frames, while continuously taking account of progress made, and review plans where necessary.

4. Preliminary lessons learned and good practices

In the previous section, a number of case studies have been assessed, varying in focus, scope, approach and national context. They cover mitigation and adaptation-related activities, different sectors, top-down and bottom-up approaches to stimulate innovation, focus on different barriers to innovation and different functions of innovation systems and different country groupings. And while additional case study analyses are likely to complement and strengthen the empirical basis, a number of broader observations can already be shared in terms of good practices and lessons learned. Table 9 summarises the cases.

Table 9 Summary of key lessons learned for each of the case studies

Case	Focus	Lessons learned

India BEE	• Mitigation
	  ○ energy demand
	• Top-down
	• Main IS functions:
	  ○ F1 Knowledge development & diffusion
	  ○ F2 Entrepreneurial experimentation
	• F3 Market formation International support received:
	  ○ Some of the initiatives tapped on international technical expertise, e.g., S&L Programme drew on the expertise of CLASP.
	  ○ Engagements with CLASP also facilitated funding opportunities with USEPA, USAID, etc.
	  ○ The standards used in the UJALA programme were devised by an international expert group.
		• A tailored approach is required as innovation needs vary
		• Bridging sector-specific gaps is key
		• Innovation activities need to be strategic, iterative and evolutionary
		• Coordination and integration of NSI elements is crucial
		• Strategic prioritization of focus sectors improves efficiency, credibility and legitimacy

Kenya CIC	• Mitigation & adaptation
	  ○ Energy, agriculture, water, waste management
	• Top-down
	• Main IS functions:
	  ○ F F1 Knowledge development & diffusion
	  ○ F2 Entrepreneurial experimentation
	  ○ F3 Market formation
	  ○ F5 Resource mobilization
	• International support received: ??
	  ○ International support and collaborations (consortiums) to build local technical and innovation capacity, project management capacity, etc. For instance, CTCN is working with KCIC to help Kenyan SMEs adopt efficient technologies[241].
	  ○ International support to generate funds for R&D, innovation, projects, etc.
	  ○ International support to mobilise policy and market action to create an enabling setting for climate action
		• Organizations need to evolve and diversify with time to achieve the ultimate goals
		• Collaborative, multi-actor partnerships are crucial for effective climate action
		• Funding model design needs to be sector and innovation cycle phase-specific
		• Full integration with host country development objectives is needed for effective outcomes
		• Local actors' engagement in the design is crucial for effectiveness
		• Effective interaction among local actors is vital for peer learning
		• International institutions and collaborations can help build local institutions and networks

Haiti DRR	• Adaptation
	  ○ Disaster Risk Reduction in all sectors
	• Top-down & bottom-up
	• Main IS functions:
	  ○ F1 Knowledge development & diffusion
	  ○ F5 Resource mobilization
	  ○ F6 Legitimation
	• International support received:
	  ○ Technical cooperation and capacity building for elaborating the national plan from e.g, UNEP
	  ○ Funding from bilateral donors for educational and training programs
	  ○ Financial support for disaster recovery from multilateral and bilateral institutions, including the Caribbean Catastrophe Risk Insurance Facility (CCRIF)
	  ○ Contribution from volunteers e.g, the Sahana Open Source Software
		• Taking a systemic perspective is important
		• Local knowledge and needs need to be taken on board
		• Strong networks are crucial in coordination
		• Combined top-down and bottom-up efforts can create synergies
		• Systemic change requires time
		• Long-term planning and review are important
		• Multi-stakeholder partnerships, including international collaboration is important

[241] Oscar, Kevin. (2020). Businesses In East Africa Set To Benefit From New Programme. February 21. 2020. https://www.kenyacic.org/2020/02/innovation-in-design-3/ (accessed on August 15, 2022).

Table 10 organizes the case study-specific lessons learned from table 9 in the previous section into similar lessons – or lessons related to similar characteristics - across case studies. This is translated further into common success factors.

Table 10 Comparison of lessons across case studies

India BEE	Kenya CIC	Haiti DRR
Strategic prioritization of focus sectors improves efficiency, credibility and legitimacy	Full integration with host country development objectives needed for effective outcomes	Taking a systemic perspective is important
- A tailored approach is required as innovation needs vary - Bridging sector-specific gaps is key	Funding model design needs to be sector and innovation cycle phase-specific	
Coordination and integration of NSI elements is crucial	Collaborative, multi-actor partnerships are crucial for effective climate action	Multi-stakeholder partnerships, including international collaboration, is important
	Effective interaction among local actors is vital for peer learning	Strong networks are crucial for effective disaster risk management and reduction
	Local actors' engagement at the design stage is crucial for effectiveness	Local knowledge and needs need to be taken on board
	International institutions and collaborations can help build local institutions and networks	Combined top-down/bottom-up approaches can create synergies
Innovation activities need to be strategic, iterative and evolutionary	Organizations need to evolve and diversify with time to achieve the ultimate goals	- Long-term planning and continuous review are important - Systemic change requires time

The above leads to the following, more generalized lessons learned and good practices.

1. A systemic perspective, integrated with host country development objectives (all cases)
   Since innovation needs vary from sector to sector, the setup and implementation of the (relevant portions of the) NSI requires the strategic prioritization of sectors – in accordance with national policy goals and socio-economic objectives. Once the prioritization of sectors has taken place, and the interactions between mitigation, adaptation and sustainable development are clear, then it is possible to define with some specificity what are the innovation pathways and needs.

2. A tailored approach to bridging sector- and innovation phase-specific gaps (all cases)
   A tailored approach allows a comprehensive understanding as well as gaps and barriers relating to specific sectors and specific phases of the innovation cycle within the system perspective of a country's innovation needs. It therefore points towards the innovation system functions that need to be addressed as well as the actors, institutions, networks, and resources that can help in this process for specific sectors. The systemic approach (#1 above) then helps to create supra-sectoral synergies where possible.

3. One common and significant feature of the case studies (particularly BEE and KCIC examples) is that the initiatives are being led by people and/or organizations with a broader and nuanced understanding of the local innovation system. This helps in engaging the right kind of actors, marshaling the right kind of resources, identifying and addressing the gaps in the innovation process, and tapping into the complementary structures and processes of the overall innovation system to advance the climate initiatives. The leading organizations are suitably placed to act as 'integrators' or 'coordinators' of the various structural and functional aspects of the innovation system. The overarching and interactive functioning of the leading organizations facilitates the process of capacity building, generation of funds, and development of enabling policy frameworks.

4. Participation of local actors and inclusion of local knowledge and coordination among actors (all cases)
   Participation of local actors is key since they have the best understanding of local context and institutions and therefore are best placed to help address gaps in NSI functions such as development and diffusion of knowledge, legitimation, resource mobilization, etc.. Interactions between actors are central to all functions of innovation systems, whether it is the development and diffusion of knowledge, resource mobilization, market formation, or legitimation. Therefore, promoting such interactions is critical, whether they are among knowledge institutions such as universities, between knowledge institutions, firms, and government agencies, between firms, between government agencies and so on. Peer learning among local actors is particularly critical since they are at the heart of any NSI.

5. Engage with international institutions and collaborations to help build local institutions, networks (KCIC, Haiti DRR)
   International institutions can play an important role in strengthening NSIs by bringing in global best practices, assisting with development, adaptation and diffusion of new technologies, helping mobilize financial and technical resources, and building capabilities of local actors and institutions. But engagement with such institutions is likely to be most effective when based on an understanding of local innovation needs and gaps.

6. Ensure that innovation and organizations are evolutionary and able to adapt to new circumstances (all cases)
   The innovation context, capabilities, and resources change capriciously over time and therefore so do innovation needs. As a result, innovation processes and institutions have to be able to adapt to the changed circumstances so as to remain relevant and effective. This may mean engaging with new actors or addressing new functions of the NSI. And it may also mean that organizations themselves evolve over time.

7. Pay attention to long-term planning and continuous monitoring and review (all cases)
   Integration with host country objectives requires a long-term planning. At the same time, systemic change takes time, during which the innovation context constantly evolves, also being non-linear. The sustainable development landscape also evolves continuously. Therefore, continuous monitoring and evaluation of innovation outcomes, and adaptability in accordance, takes on great importance. The insights from such monitoring and review can be used to improve the setup and implementation of the NSI, thereby creating a dynamic situation where the NSI is able to evolve in response to the new knowledge and understanding. It can provide a better understanding of long-term policy goals to innovation actors, allowing for course correction, when and where needed.

As mentioned above, these preliminary insights are based on the 3 case studies carried out so far. When further case studies have been carried out, the above will be updated to reflect further lessons and insights in the next version of this compilation.

5. Preliminary conclusions & recommendations

The case studies covered in this compilation illustrate and underline the value of taking a systematic approach to strengthening relevant parts of national systems of innovation that can then support and advance climate action through scaled up development and diffusion of climate technology.

The framework presented in the Section on the Approach to understanding NSI performance for climate action (Tables 1-3) highlights the functions required of an effective NSI, the kinds of resources required to support these functions, and the structural elements that might need attention to allow fulfilment of these functions. The NSI functions and the structure-function frameworks outlined there can serve to guide the systematic approach to implement the NSIs to advance climate action.

These frameworks also indicates that the specific nature of the functions, resources, and structural elements required will vary from sector to sector, as illustrated by the case studies. This emphasizes that rather than try to strengthen the NSI in the abstract, it makes sense to focus efforts at enabling specific climate action. In other words, if the climate action is, for example, energy-efficiency-related, then the NSI may need to strengthened in a different way than in the case that climate action is e.g. related to renewable energy supply. This is not to say that efforts at strengthening the NSI more generally are not useful – they also are, as noted below – but since what is needed to support climate innovation and action is quite sector-specific, targeted efforts are necessary.

This, of course, then leads to another point highlighted by the case studies. If the requirements of the NSI are sector-specific, then a prioritization of focus sectors has to be the first step. As the BEE case highlighted, the initial areas of focus were chosen after some careful deliberation, taking into account the local context. The KCIC also took a similar approach at prioritizing specific areas in the broad context of climate innovation. And the actions highlighted in the Haiti case all were driven by an understanding of the need to strengthen disaster response. In all these cases, the upfront identification of priorities guided the actions required to support relevant elements of the NSI.

Once the priorities are identified, though, then mapping the NSI before designing and implementing strategies helps create the needed understanding of the state of the functions, structural elements, and resources of the innovation system. This can help identify gaps in the innovation ecosystem that need to be addressed and that, in turn, make it possible to identify strategies to fill these gaps. This may involve strengthening and emphasizing functions of the innovation ecosystem such as market creation and resource mobilization. It may also involve strengthening actor networks and coordination, as all the cases highlighted, including linkages among local actors, between local and international actors, and between researchers and entrepreneurs. Building synergies with local policies and priorities greatly supports the legitimation function.

The role of local knowledge in guiding these actions cannot be over-emphasized since they all require a thorough understanding of the local context and needs. At the same time, international collaboration to may be particularly useful not only for knowledge development and diffusion but also building capabilities of local actors as well as harnessing financial and technical resources. Another clear conclusion from the case studies is the importance of learning from experiences and using that learning to continuously improve efforts intended to strengthen various elements of the NSI, especially in relation to evolving context.

Another vital and common feature of the case studies is that the initiatives are led or managed by organizations with a holistic understanding of the local innovation system. Since the leading organizations are conversant with the structural and functional aspects of the overall innovation system, they are adequately placed to evaluate the available capabilities, identify the missing links, and develop the requisite resources at the right stages of the innovation cycle. They are also suitably positioned to draw on the complementary resources frameworks of the larger innovation set-up in the country.

One last point is implicit in the case studies: efforts to advance climate action eventually are embedded in the local context and draw upon local resources. Therefore, strengthening local actors such as universities and other academic institutions, deepening linkages between such knowledge entities, private actors and government agencies, and building a culture of experimentation and learning will serve to strengthen the NSI more broadly and therefore also facilitate climate action in specific sectors.

Based on the above, the overall recommendation from this study, drawing from the case studies, is that:

(a) A systematic approach be undertaken to implement the NSI to advance climate action, using the NSI functions and the structure-function frameworks as the overarching guide;

(b) This approach should help ensure that the NSI is performing the relevant functions, which may require strengthening of NSI functions, marshalling of resources, and addressing weaknesses/gaps in structural elements in NSIs.

But as these are specific to sectors, it is recommended the above builds on an initial identification of sectoral priorities, aligned with national policy goals and socio-economic objectives.

Good practices for potential replication that have been identified in the various case studies lead to the following specific recommendations:

- *Map the NSI before designing and implementing strategies:* Such mapping helps create the needed understanding of the structural elements and functions of the innovation system, barriers and missing links in the innovation ecosystem, crucial actor groups, state of resources and capabilities, potential synergies and trade-offs between other initiatives and policy structures, and the role of international collaborations.
- *Look for win-win measures:* It is important to design win-win strategies (through innovative governance and market models) to ensure participation by all relevant stakeholders and minimization of the risk factors.
- *Coordinate and integrate with long-term policy framework:* It is essential to ensure that the initiative is in synergy and integrated with the overall policy framework of the country and that it facilitates the larger development and climate objectives of the region.
- *Learn iteratively:* Design learning mechanisms so that the impact of the strengthening of functions and the structural elements, or a change in the characteristics (opportunities, strengths, needs, etc.) of the context in which the initiative is being implemented can lead to further strengthening in an iterative way.
- *Create complementary knowledge and servicing infrastructure*: In order to promote and implement technological innovations effectively and consistently (in the long term), the creation and sustenance of complementary knowledge, skill sets, and trained human resource base must be facilitated. This will also aid in monitoring, measuring, and upgrading technological innovations.
- *Allow flexibility in how policy goals are met*: This is particularly relevant in a developing country context. Where possible, the policy goals and aspirations can to be highlighted, with the stakeholders given the flexibility adopt the technology/means best suited to them to achieve those goals (e.g. be technology-neutral). This will generate credibility for the regulator's actions, manage risk perceptions of the stakeholders, and facilitate faster attainment of the policy goals.
- *Establish a clear role for a coordinating agency*: In situations where diverse stakeholders need to come together to make an intervention/innovation effective, the role of coordinating agencies or 'system operators/integrators' becomes important. Coordinating agencies with a holistic understanding of the strengths and flaws of the overall innovation system of the country can organize the actions of different stakeholders, address the system gaps, tap into the system resources and respective strengths of the actors, and maximize the network impacts.
- *Use international collaborations to develop local capabilities and resources*: International partnerships and exchanges should be used to develop local technological, financial, political, and human resources. Local actions should be aimed at using international support to create an enabling ecosystem for climate action in the long term and not be limited by a project-based mode of operation.
- *Evolve and diversify through learning by doing*: International funding and guidance should be used to kick-start an initiative. However, organizations should develop their capabilities and expand their intervention areas to become independent and effective entities with sustained relevance in response to the evolving characteristics of the local context.
- *Design innovative, customized, and flexible funding frameworks*: Devise funding models to suit the stage, scope, and risk perception of the innovators/firms. Complement the funding schemes with enabling policy and financial regimes for effective and sustained outcomes.
- *Pay attention to market creation for climate technologies*: For a mature and effective ecosystem for green entrepreneurship, policies, market structures, and actor capabilities should be directed towards creating sustained demand and supply dynamics for clean technologies.
- *Engage both public and private sectors*: Ensure the participation of diverse stakeholders to address the complexities and uncertainties associated with innovation processes. This will also help in tapping into the different capabilities and skill sets of various actors.
- *Integrate the goals of climate initiatives with the local policy goals and socio-economic priorities*: Synergies with local objectives will help in enhanced participation by stakeholders and minimize risk perceptions. This includes issues such as gender parity, employment for youth, etc.
- *Focus beyond hardware innovation:* Technological hardware can have an important contribution to mitigation and adaptation goals. However, this should be combined with building the capacity of local actors, creating the right communication channels for sharing knowledge and information, and establishing the right regulatory framework for an effective strategy to scale up implementation of climate technology.
- *Strengthen local capabilities, while ensuring coordination:* strengthening local capabilities is crucial for effective action. However, there is also a need for harmonization of curricula, protocols and information management mechanisms. Finding

the right balance between bottom-up and top-down processes can be challenging, but can contribute to more effective strategies.

- *Plan according to longer time frames, while allowing monitoring, evaluation and review:* Since systemic change requires time, short-term planning (with too short time frames covering only a couple of years) will only be effective to a limiting degree in achieving objectives. It is therefore important to plan according to longer time frames, while continuously taking account of progress made, and review plans where necessary.

These preliminary recommendations, based on the 3 case studies carried out so far, will be updated to reflect further lessons and insights in the next version of this compilation when further case studies have been carried out.

Acronyms

AC	Air Conditioner
BEE	Bureau of Energy Efficiency (India)
BIS	Bureau of Indian Standards (India)
CCRIF	Caribbean Catastrophe Risk Insurance Facility (Haiti)
CDM	Clean Development Mechanism
CDEMA	Caribbean Disaster Emergency Management Agency (Haiti)
CFl	Compact Fluorescent Lamps
CIC	Climate Innovation Centre
CLASP	Collaborative Labelling and Appliance Standards Program (India)
CTESP	Thematic Committee for Education and Public Awareness (Haiti)
CTP	World Bank infoDev's Climate Technology Program
DANIDA	Danish International Development Agency
DFID	UK Department for International Development
DISCOMS	Electricity Distribution Companies
DPC	Directorate for Civil Protection (Haiti)
DRF	Disaster Risk Financing
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EWS	Early Warning Systems
EC	Energy Conservation
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited
EFSM	Early-Stage Finance Mechanism (Kenya)
EOC	Emergency Operations Centers
ESCerts	Tradable energy saving certificates
ESCO	Energy Service Company
FAO	United Nations Food and Agricultural Organization
GACI	International Cooperation Support Group (Haiti)
GHG	Greenhouse Gas
GOI	Government of India
GrEYAP	Green Economy Youth Activation Programme (Kenya)
HDI	UNDP's Human Development Index
HSDP	Haiti Strategic Development Plan (Haiti)
IFRC	International Federation of Red Cross and Red Crescent Societies
INR	Indian Rupia
KCIC	Kenya Climate Innovation Centre
KCV	Kenya Climate Ventures (Kenya)
KENIA	Kenya Innovation Agency (Kenya)
MoU	Memorandum of Understanding
MTEE	Market Transformation for Energy Efficiency (India)
MTP	Medium Term Plan (Kenya)
NACOSTI	National Commission for Science Technology and Innovation (Kenya)
NAPCC	National Action Plan on Climate Change (India)
NCCAP	National Climate Change Action Plan (Kenya)
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
NMEEE	National Mission on Enhanced Energy Efficiency (India)
NRF	National Research Fund (Kenya)
NSI	National System of Innovation
PAT	Perform, Achieve, Trade programme (India)
PNGRD	Plan National de Gestion des Risques et des Désastres (Haiti)

PoA	Programme of Activity under the CDM
PPP	Public-Private Partnerships
PSDH	Strategic Development Plan of Haiti (Haiti)
R&D	Research & Development
ROSHANEE	Roadmap of Sustainable and Holistic Approach to National Energy Efficiency (India)
SADC	Swedish Agency for Development and Cooperation
SDGs	UN Sustainable Development Goals
SERC	Strathmore Energy Research Centre (Kenya)
SIDS	Small Island Developing States
S&L	Standards and Labelling programme
SME	Small and Medium-size Enterprises
SNGRD	Système National de Gestion des Risques et des Désastres (Haiti)
SOR	Sahana's Organization Registry (Haiti)
STI	Science, Technology and Innovation
TEC	Technology Executive Committee
TIS	Technology Innovation System
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
US AID	United States Agency for International Development
US EPA	United States Environmental Protection Agency

Acknowledgments

[to be added later]

References

[*In this version references are mentioned in footnotes. They will be moved here later*]