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ORIGINAL ARTICLE

Profiling national institutional archetypes for climate change technology implementation: application in small islands and least developed countries

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Abstract
In developing countries, when the implementation success of new climate adaptation and mitigation technologies fall short of expectations, the typical "suspects" cited are lack of funding or country expertise and allusions to "lack of institutional capacity." The premise of this study is that the national institutional environment is the fundamental prerequisite for successful technology implementation, and despite much effort, a diagnostic approach to assessing this prerequisite is missing. Here, I propose an approach to do this, based on an understanding of the dynamics that interconnect country-level legal, regulatory and market mechanisms, societal norms, and inter/intra governmental structures. I estimate levels of country structural and systems supports, operating environment, implementer acceptance and country tractability. A preliminary test of the approach was completed through a survey of experts involved in the United Nations Technology Needs Assessment programs in Least Developed and Small Island Developing Countries. It was found that countries fall into four fundamental archetypes. A country's archetype suggests characteristics of the institutional environment that help to explain the potential for technology implementation success. A further implication is that some countries that typically would not be considered very similar may possess similar country institutional environments. One consequence of this is that archetype-based groups could work together and learn from each other more effectively.

Keywords Climate technology · Technology implementation · Institutional theory · Technology needs assessment · Small island developing countries · Least developed countries

1 Introduction

1.1 Climate technology implementation in developing countries

An ongoing challenge for developing countries in effectively addressing climate change is the lack of appropriate climate technologies (Olawuyi 2018). But even when such

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technologies are acquired and transferred, many of these countries still have challenges in the implementation process. Technology implementation refers to the process of learning, utilizing, adapting to local conditions, and integrating these technologies into indigenous technological systems (IPCC 2000; UNFCCC 2012; Olawuyi 2018). The development and transfer of new technologies have mostly been concentrated in industrialized countries, and for countries that could not produce the needed technologies for lack of financial, economic, and technical capacity reasons, they resorted to importing foreign technologies from industrialized countries to assist in their own development. Studies of technology implementation in developing countries have revolved around industrial development (Lall 1995; Archibugi and Pietrobelli 2003; Lall and Pietrobelli 2005; Chittoor et al. 2015), but there is insufficient discussion on the implementation of climate technologies and sustainable development. Other researchers have identified gaps in studies of human capabilities to understand relevant climate technologies, legal and regulatory frameworks, aspects of social acceptance, and how to mesh imported technology with local traditions, practices, norms and culture (Olawuyi 2018).

When climate technologies are scarce or unavailable domestically, it means that skills and technical knowhow and structural settings for effective implementation are also not available. Several articles have discussed this situation in Small Island and Least Developed Countries when it comes to financial, regulatory, and technical issues regarding the acquisition of climate technologies, its deployment and use, and the poor policy environment that impede the growth and slow down domestic implementation of climate technologies (Dornan 2015; Dornan and Shah 2016; Timilsina and Shah 2016; Lucas et al. 2017; Keeley 2017; Michalena and Hill 2018; Michalena et al. 2018; Surroop et al. 2018), but an assessment of the institutional environment for climate technology implementation has not been explored.

Governments play an important role in developing the institutional and technological capabilities of their countries. In the climate change realm, governments can work to monitor the inflow of technologies and the way these technologies help in reducing foreign dependence by implementing various programs and policies. This includes raising research and development spending; upgrading the country's science and technology infrastructure; reforming laws, procedures, bureaucratic rules, and organizational cultures that can interfere with the technology implementation process; improving public institutions, and setting up incentives schemes among other initiatives to help "bundle" the technology package (Kumar et al. 1999). In addition, besides the government, actors such as development agencies, utilities, financial institutions, civil society, private sector, and NGOs should be better included in decision-making or what is now summarized as the triple helix model (Leydesdorff and Zawdie 2010).

These shortcomings are acknowledged in United Nations sponsored Technology Needs Assessments (TNAs) of all LDCs–SIDS. It puts into perspective, the need for assessing the current institutional environment for technology implementation at the national level and eventually calls for a holistic and full-scale climate technology diffusion plan—an approach that is consistent with the broader political, economic, and social setting of a country rather over "patchwork remedies." I propose a conceptual framework to assess the institutional environment of LDCs–SIDS to implement climate technologies domestically and use the framework to test whether the current national institutional regimes of LDCs–SIDS are conducive to implementing the technologies prioritized in their TNAs. Without a framework put in place to understand the implementation of these technologies, the gap between climate technology transfer and effective domestic implementation of these technologies will inhibit progress in addressing climate change (Olawuyi 2018).

Characterizing the institutional environment is useful in determining the future institutional changes that LDCs–SIDS can undertake to strengthen their national capacities for more effective climate actions or allow LDCs–SIDS to assess their current institutional capacity and select those actions and climate technologies that can be implemented within their existing capacity.

Here, I am not assessing whether the technologies listed in LDCs–SIDS TNAs are appropriately selected or not. Instead, the interest here is in how prepared LDCs–SIDS are to effectively implement these technologies. While the TNAs look for ways to effectively transfer low-carbon technologies, we look into the institutional environment at the receiving countries and discuss whether this environment facilitates optimal implementation.

The framework put forth here can thus be regarded as complementary to the TNA. The framework is inductively formulated based on insights from over ten years of research and consulting work in these countries, in environmental policy by the authors, and based on the relevant literature. While it is an initial foray, it clearly provides an extension to the climate technology implementation literature and a practical approach for practitioners in the field. Through our proposed framework, we establish the reasoning behind the enabling environment for climate technology implementation and through a "readiness" criteria survey with experts, we present an initial testing of the framework logic. The findings give encouraging evidence that the framework can provide new insights about the country's institutional environment pin-pointing towards potential climate technology implementation success or failure beyond the usual suspects. Our article also provides an alternate way of looking at solutions to technology implementation barriers over simple "patchwork" solutions. Under the lens of our framework, we can identify where efforts and resources can be concentrated if a more effective deployment of technologies in LDCs–SIDS is to be achieved.

The article is structured as follows: Section 2 discusses the importance of technology implementation as a fundamental element of the technology diffusion process and Sections 3 and 4 describe our proposed framework. In Section 5, we detail our survey process and results and use them to assess the preparedness of LDCs–SIDS to implement their prioritized technologies listed in their TNAs. Lastly, in Section 6, we present our conclusions of our analysis and recommendations.

1.2 Current approach to assessing country climate technology needs

At the 7th Conference of Parties in 2001, the least developed countries were encouraged to undertake "Technology Needs Assessments (TNAs)" to identify climate technology priorities. Donors and technology investors would then consider such assessments in their lending strategies (UNFCCC 2002; Charlery and Trærup 2019). Despite this, LDCs and SIDS remain among those countries with the lowest deployment of climate technologies (Olawuyi 2018). A reason for this is the failure of implementers to adjust approaches to the unique institutional environments in these countries (Olawuyi 2018). From 2001 to 2018, 90 countries completed TNAs. As from 2018, 23 more countries have started their TNAs of which 13 countries have never undertaken the TNA process before (Hofman and van der Gaast 2019). Several TNA reports have become outdated but there is a new thrust targeting LDCs–SIDS to submit TNA reports and potentially access relevant climate technologies. As part of this effort, the TNA process has provided a compelling analytical approach that allows participant countries to identify and prioritize technologies worth deploying (Step 1 of the TNA process), study barriers to transfer and domestically deploy these technologies

(Step 2), and formulate an action plan based on a more in-depth examination of barriers and applied solutions to achieve deployment of prioritized technologies (Step 3)[1]. The TNA process however focuses on a few sectors to formulate climate actions. For mitigation purposes, LDCs–SIDS have prioritized the energy, transport, and forest- and land-use sectors, and for adaptation purposes, the focus was mainly on water, agriculture, and coastal zone management sectors. In general, technologies prioritized by participant countries can be categorized as follows: (a) consumer goods (destined for the mass market, for example, distribution of Compact Fluorescent Bulbs, deployment of off-grid solar PV installations); (b) capital goods (heavy equipment and machinery like biomass power plants, heat recovery systems, large scale solar farms); (c) publicly provided goods (infrastructure projects like constructing seawalls and groynes, rock revetment, wetland restoration); and (d) non-market goods which include training for particular technologies, though these categories can be overlapping (Nygaard and Hansen 2015).

Despite these efforts, the challenge of implementing climate technologies in response to TNA studies remains in relative malaise in many developing countries (Olawuyi 2018; Hofman and van der Gaast 2019). So much so that TNA reports now have to be redone since they are so old and technologies have become so much more advanced that the original reports are archaic. Reasons for this state have often been attributed to programmatic elements of the TNA framework itself, where for example, interventions recommended are blurred between technologies, organizations, and institutions with little directive on prioritizations or interesting dynamics between them. The lack of incorporation of national political and cultural contexts in implementation plans has also been critiqued (Nygaard and Hansen 2015). But beyond these programmatic problems and arguably far too muted, there is an understanding that the state of the country's institutional environment is a fundamental precursor to many, if not all of these challenges being laid out. Understanding and adjusting elements of this deeper institutional environment could therefore make it easier to navigate some of these programmatic challenges.

2 An institutional theory framework of climate technology implementation

Institutional actors in developing countries are subject to incentives and pressures that can encourage climate technology implementation. These actors respond to such drivers in order to maintain their legitimacy on the issue. Maintaining institutional legitimacy could mean that they adopt new behaviors, formal structures, policies, social norms, values, and cultural systems (Meyer and Rowan 1977; DiMaggio and Powell 1983; Lee et al. 2013; Zhang and Zhou 1995). Three kinds of isomorphic institutional pressures can be at play: coercive pressure, normative pressure, and mimetic pressure (DiMaggio and Powell 1983).

Coercive pressure is derived from formal rules and regulations imposed through established authority structures. For example, multilateral banks attach conditions to loans for particular projects to ensure that recipient countries maintain good policy and economic environments (see Larmour 2002) which is a form of coercive pressure. Coercive pressures result also when the government imposes regulations on domestic firms forcing them to invest in clean technologies—for example, regulating carbon dioxide emissions to push firms' energy-saving behavior. Normative pressure is a result of professionalization which

[1] More details on conducting TNAs can be found here: https://tech-action.unepdtu.org.

is the “collective struggle of members of an occupation to define the conditions of their work and to establish a cognitive base and legitimization for their occupational autonomy” (DiMaggio and Powell 1983). For example, with more interactions between industry associations and environmental NGOs, normative pressures permeate through the channels of professional affiliations and influence industrialists to set up basic norms towards environmental protection (DiMaggio and Powell 1983; Teo et al. 2003; Liang et al. 2007). Civil society can also be influenced by media coverage and push for more environmentally benign goods and services as well as more efforts at governmental and firm levels to implement low-carbon technologies. Mimetic pressure occurs when, in this case, countries perceive that their peers or even competitors are achieving success in their climate actions by adopting and implementing new technologies. This can force or inspire some countries, their governments, or policy makers to follow the lead of those more successful countries in technology implementation. These pressures therefore create “pulling” incentives and “pushing” forces across agencies, institutions, and actors, thereby creating unique country institutional environments that make technology implementation more or less successful.

2.1 The national institutional environment

Berry and Berry (1990, 2018) view “diffusion” and “internal determinants” as pre-requisites for policy implementation in any country’s environment. Diffusion explanations are intergovernmental, that is, they refer to the influence that one country has on another one in the form of “incentives” or “pressures” (i.e., institutional pressures). So, one branch or agency of government in a country can influence the technology-oriented decisions through the same institutional pressures in another country. Additionally, internal pressures come from the inherent social, economic, and political characteristics of a country (Shah and Niles 2016). Institutional pressures, as described above, are key shapers of the institutional environment consisting of structures, functions, processes, and actor relationships that work together to determine if a technology can be implemented successfully or not. These neo-institutional pressures shape the countries’ environment in different ways, influencing and even dictating how and why actions occur through the actors, governmental agencies, and influential organizations. These pressures also establish ground rules such as the set of laws, practices, policies, and norms through which interaction between institutional actors occurs and implementation of climate technologies is promoted.

LDCs–SIDS fundamentally need sufficient human resources and a learning environment where knowledge is acquired. Reforms to create this institutional environment depend on competent and motivated government personnel, but good reform programs have often been formulated without knowing who will implement them (Schiavo–Campo et al. 1997). Without a professional civil service, policy implementation never translates into actions (Schiavo–Campo et al. 1997). On the other hand, if organizations and local agencies are understaffed, this means that practitioners are likely to cover many issues causing a productivity problem. The situation gets more complicated with the unavailability of highly qualified practitioners common in LDCs–SIDS and more complex when many high-ranking positions are nominated rather than meritocratically selected (Shah et al. 2020). This leads to a shortage of experts in key decision-making positions and a dampening in motivation for many practitioners (Willems and Baumert 2003). The institutional structure thus relies on getting the right human resources in the right places to work in a more systemic manner. Additionally, often organizations work in silos and what result from them are isolated initiatives (Willems and Baumert 2003). The institutional environment connects actors and allows multilevel and dynamic interaction among them. This interaction may be technical, legal, social, or financial inasmuch as the goal is the implementation of climate technologies. This interaction can take two forms which are "vertically" within organizations (intra-organizational) and "horizontally" among organizations (inter-organizational). If members of an organization or across organizations do not share information in a bureaucratic model, they severely constraint interoperability, information, and knowledge flow, and this weakens the ability of members to create this learning environment and integrated solutions as are needed in the case of technology implementation (Yang and Maxwell 2011). As Mander (2007) finds, the more there are institutional actors with relevant capacities and interaction among them for building coalitions, the better the implementation of projects or policies. The actions of institutional actors and the ways they interact depend largely on three sets of conditions: (a) a proper legal and regulatory environment, (b) the presence of conducive market and financial incentives, and (c) adequate and acceptable social norms and behaviors among all institutional actors.

These legal and regulatory provisions can be the alignment of policy actions with national objectives and the existence of the appropriate laws that allow participation of private and public sectors in implementing technologies. Legal, regulatory, and policy instability, in effect, signals uncertainty to prospective investors, and as a result, private investment in climate mitigation and adaptation sectors becomes a risky venture (Shah 2021). A regulatory framework also provides a foundation for adequate market and financial mechanisms to promote climate technologies—subsidies and tax breaks for examples are known to incentivize investors and their presence can facilitate technology implementation by reducing risks. Another condition is integrating climate technologies with country-accepted norms or "nudging" users to see the benefits of technology and why it is important. There is no universally accepted set of norms, values, and practices, but understanding how to mesh locally accepted norms and practices with imported climate technologies creates a higher probability of successfully deploying the technology. Acceptability issues regarding climate technologies create problem on the consumer side. If actors like governmental agencies are supplying the technology beneficial for all, the reluctance of the civil society to consume those products, technologies, and services creates a deployment problem, and without considering those aspects of technology implementation, failure is not to be dismissed. The presence of the above-mentioned conditions and the ways that they interplay produce a unique environment for the implementation of climate technologies. But because of the sheer complexity of the institutional engine, we need a tool to help direct us to "where to look" for the components that need attention—something that current technology assessments fail to do.

3 Diagnosing the national institutional environment

A "diagnostic tool" for the national institutional environment of a given country comprises of four main criteria—(a) structural and system support, (b) operating market and environmental conditions, (c) implementer acceptance, and (d) country tractability. Figure 1 illustrates the framework and the variables that condition the technology implementation process. By looking at appropriate indicators that make up these components (see Table 1),

Table 1 Criteria for technology implementation

Criteria	Description
Criteria 1: Structural and system support	
CR 1.1	Clear technology national objectives
CR 1.2	Formal Best practice references and experts to rely on
CR 1.3	Financing in place or identified or allocated
CR 1.4	Inter and Intra agency integration for implementation
CR 1.5	Rules of procedures clearly articulated
CR 1.6	Human resources ready to support deployment
CR 1.7	A knowledge and learning environment for technology
Criteria 2: Operational market and environmental conditions	
CR 2.1	Supportive prevailing socio-economic conditions
CR 2.2	Competing target sector needs
CR 2.3	Public and media attention to challenge
CR 2.4	Public support for prioritized technological solution
CR 2.5	Advocacy from technology entrepreneurs
CR 2.6	Political support gathered over implementation
CR 2.7	Market conditions incentivizing implementation
Criteria 3: Implementer acceptance	
CR 3.1	Perceived as useful
CR 3.2	Target users want to use
CR 3.3	Target users have previous experiment with technology
CR 3.4	Technology is not niche but mainstream
CR 3.5	Manageable operating cost and technology durability
CR 3.6	Target users have official training with technology
CR 3.7	Market-based mechanisms available
Criteria 4: Country tractability	
CR 4.1	Availability and accountability of technological solution
CR 4.2	Diversity of target sectors
CR 4.3	Target sectors alignment with climate goals
CR 4.4	Number of target sectors alignment needed

we can eventually deduce how conducive it is to promote the implementation of climate technologies.

- *Structural and systems support* is created in response to the formal, regulatory, and legislative mechanisms of the institutional environment. Support systems could have national, multisectoral, or target sector mandates. Table 1 details the criteria that make up the structural and systems support component. Prior evaluative studies have pointed towards shortfalls in the domestic deployment of climate technologies in SIDS—Atteridge and Savvidou (2019) have shown SIDS (including some LDCs) have got little development assistance from donors which denotes the needs of diversifying means of finance of climate technologies to the public and private sector for financing to be in place. In addition, others have pointed towards the low knowledge and skills based on LDCs–SIDS slowing down domestic diffusion of technology (Lucas et al. 2017); the needs for standardization of market-based technologies to ensure quality (Shah et al. 2021) and, to the least,

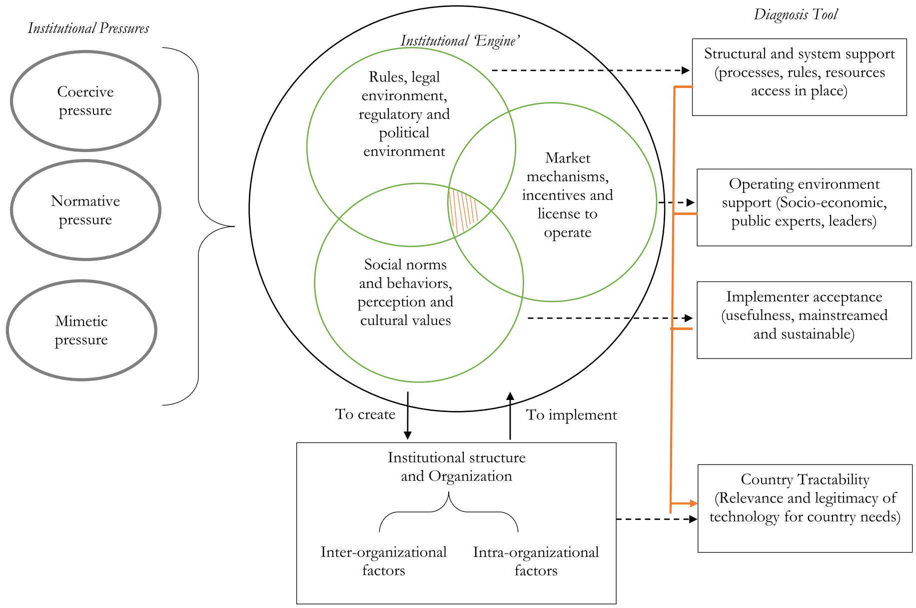

Fig. 1 The components of the"institutional engine" paradigm

the presence of dedicated agencies to look into climate and related issues (Surroop et al. 2018). Thus, these criteria include declarations of national targets for technology transitions (Iyer et al. 2015), best practice and global standards frameworks (Chen et al. 2014), financing (Jakob et al. 2015), recognized national administrative processes and procedures (Rykkja et al. 2014), advisory committees of experts and systems for knowledge diffusion and absorption (Hakelburg 2014) that we argue, produce a robust structural system for technology implementation. In simpler terms, we argue that the criteria (C.R 1.1 to 1.7) provide an answer to what extent do LDCs–SIDS have the necessary legal, regulatory, and political environment to promote climate technologies implementation.

- The second criterion is with regard to o*perational market and environmental conditions*. Some technologies (for example, climate-resilient consumer goods as mentioned earlier) are influenced directly by market conditions and indirectly by some political influences. Other technologies (for example capital goods) require direct governmental intervention for successful deployment in the form of financial incentives like preferential loans and guarantees or by creating favorable conditions for private investors. This goes into establishing an efficient system for project implementation (Nygaard and Hansen 2015). Market pressures, incentives, and prevailing conditions at the time that new technologies are introduced can influence societal uptake and perspectives of the effectiveness of the technologies (Bertram et al. 2015; Shah 2018). Convincing potential implementers to interface with the technology is also not only a cost-benefit decision. Public and visible advocacy for new technology from the political directorate (Hakelburg 2014), media, and even the vocality of tech-savvy entrepreneurs can also enhance the implementation environment (Kaesehage 2019; Rosen and Olsson 2013). Thus, in simpler terms, the second set of criteria (C.R 2.1 to 2.7) provides an answer to what extent do LDCs–SIDS have the needed environment to promote technology on market terms with either direct or indirect intervention governmental influence.

- The third criterion is *implementer acceptance* for assessing the country's potential for successful technology implementation. Technology acceptance is a well-researched field often couched in behavioral and sociological frameworks and explores the motivations for potential users to apply a new technology. Under market terms and/or political terms, a technology can be introduced in a country, but optimal results will be achieved only if the technology is accepted by users. Sovacool et al. (2011) discuss the Solar Home System adoption problem in the Pacific SIDS of Papua New Guinea where the introduction of solar panels has been regarded as synonymous to an assault on their way of living leading to acceptability problems. There should be a need for the technology at the level of the individual or community and the perception that the technology will add value to targeted activities for example production at a reasonable cost (Khatri–Chhetri 2019). When users have observed technology pilots or received training, they have greater confidence in going to the implementation phase independently. Hence, the third set of criteria (C.R 3.1 to 3.7) provides an answer to what extent the users of a particular technology or sustainable product of a technology are willing to accept it and integrate it into daily life.

- *Country tractability* provides an idea of the solvability of the climate problem by a technological solution (Sabatier and Mazmanian 1980), and through this criterion, we seek to deduce how suitable the technological solution is to address the issue at hand. Technology gains national traction when it is available, and its advocates can be held to account for the promised performance results. When it targets multiple aligned sectors that link closely to national climate adaptation and/or mitigation goals, traction through faster scale-up diffusion is gained. Country tractability therefore indicates the effectiveness of that technology in addressing the issue at hand with the technological solution.

4 Preliminary demonstration using the institutional engine paradigm

To apply the above approach, I selected a sample of ten LDC and SIDS countries that had recently undergone TNAs and for which the country reports were available. These were Madagascar, Mauritius, Gambia, Guyana, Grenada, Zambia, Bangladesh, Seychelles, Burkina Faso, and Belize.

To apply the assessment approach, I assembled an expert panel for each of the ten countries[2]. To do this, we identified and contacted technology experts from each country or experts with strong country-level knowledge. For each country, we sought at least one government respondent (such as from the energy technology agency or environmental technology authority); one expert from a local university; and at least one representative of the business community (through the Chamber of Commerce or other business association). Through an online survey questionnaire based on Table 1, they were asked to

[2] The study started with 10 countries but during the methodological process there were difficulties in 2 countries with data, expert discussions, and obtaining approvals to use results from all experts. As a result, only 8 of the 10 countries are presented here.

respond on the 1–5 perceptual scale, and we collated the results for each country. Next, we invited each country's expert panel to a meeting with the research team and the respective TNA consultant (the authors of the UN TNA reports for each country) to a meeting to validate the results of the survey. At each country meeting, the researcher scores and the expert panel scores were discussed with the TNA consultant. Through a discourse process about the similarities and differences in scores between the researchers and experts, grounded through the in-depth experience of the TNA Consultant, a final negotiation of scores was done. Both the researchers and the expert panel reviewed and revised their scores if so desired. These final scores were collated and presented in Table 2.

Considering all the four criteria together from Table 1, Mauritius has the highest average score of 3.93 (which suggests a primed institutional environment to receive and successfully implement climate technologies), and Bangladesh the has the lowest score which is 2.59. The results also suggest that Bangladesh has very poor institutional conditions across the board—structural and systems supports; operational market and environmental and country tractability.

The diagnostic helps us point to specific dimensions of the country's institutional environment that are contributing least to potential technology implementation success. In Seychelles for example, this is c*ountry tractability*. Mauritius' 3.66 average score for *Structural and System Supports* indicates to what extent the legal, policy, and regulatory environment of the country is ready for the implementation of climate technologies listed in their TNAs. The magnitude refers to the preparedness of these aspects for technology implementation from medium to high—though more improvement is clearly needed. Similarly, Criteria 2 and 3 which have an average score of 4.18 and 3.89, respectively, point to the presence of the necessary market conditions and the level of acceptability of the technology within the national institutional system of the country. *Country Tractability*, with a 4.12 average score, indicates the alignment of Mauritius' selected technologies in achieving climate goals, as well as the effectiveness of the technological solution in addressing the climate issue. The same reasoning can be applied to other countries. Figure 2 provides more details on the survey results.

5 Findings of the assessments

The country profiles generated can be utilized in three ways: (1) identifying the "weak" institutional aspects that require improvements; (2) identifying countries with "strong" institutional aspects that we can try to replicate in other countries where these are weak; (3) identifying "clusters" of countries that have similar institutional profiles, hence creating peer-groups that can work to improve together (see Fig. 3). These are elaborated to demonstrate their usages below:

(1) *Countries with "weak" institutional regimes*

Structural and systems supports are very weak in Madagascar: This points to deficiencies in institutional rules, legal environment, and regulatory and political environment related to technology implementation. Evidence of this includes political interference where electricity tariffs are fixed too low for utility companies to stay afloat leading to less consideration of developing renewable sources, lack of regional knowledge exchange and cooperation, and bureaucratic and administrative burden, slowing down needed actions for the implementation of renewable energy projects.

Table 2 Summary of country results from the diagnostic tool

	Criterion 1: Structural and systems supports			Criterion 2: Operational market and environmental			Criterion 3: Implementer acceptance			Criterion 4: Country tractability			Overall		
	Adap.	Miti.	Avg.	Adap.	Miti.	Avg.	Adap.	Miti.	Avg.	Adap.	Miti.	Avg.	Adap.	Miti.	Avg.
Bangladesh	2.50	2.31	2.41	2.21	2.50	2.36	2.50	2.71	2.61	4.00	2.63	3.31	2.65	2.52	2.59
Burkina Faso	2.79	3.29	3.04	2.57	3.00	2.79	2.50	2.50	2.50	3.63	3.50	3.56	2.77	3.00	2.88
Belize	2.69	2.69	2.97	3.00	3.21	3.11	3.00	2.79	2.89	4.10	3.63	3.81	3.23	3.00	3.12
Grenada	2.88	2.92	2.90	3.05	2.95	3.00	3.14	2.83	2.99	3.83	3.42	3.63	3.14	2.98	3.06
Guyana	3.63	3.42	3.52	3.39	3.62	3.51	3.54	3.57	3.55	3.88	4.08	3.98	3.58	3.62	3.60
Madagascar	3.25	3.06	3.16	3.07	3.64	3.36	3.50	3.79	3.64	3.88	3.75	3.81	3.37	3.52	3.44
Mauritius	2.81	4.50	3.66	3.64	4.71	4.18	3.50	4.29	3.89	3.25	5.00	4.13	3.29	4.58	3.93
Seychelles	2.19	2.81	2.50	2.71	2.54	2.63	3.18	2.29	2.73	2.44	3.69	3.06	2.63	2.73	2.68

The highest scores for countries are highlighted in blue; the lowest scores for countries are highlighted in yellow

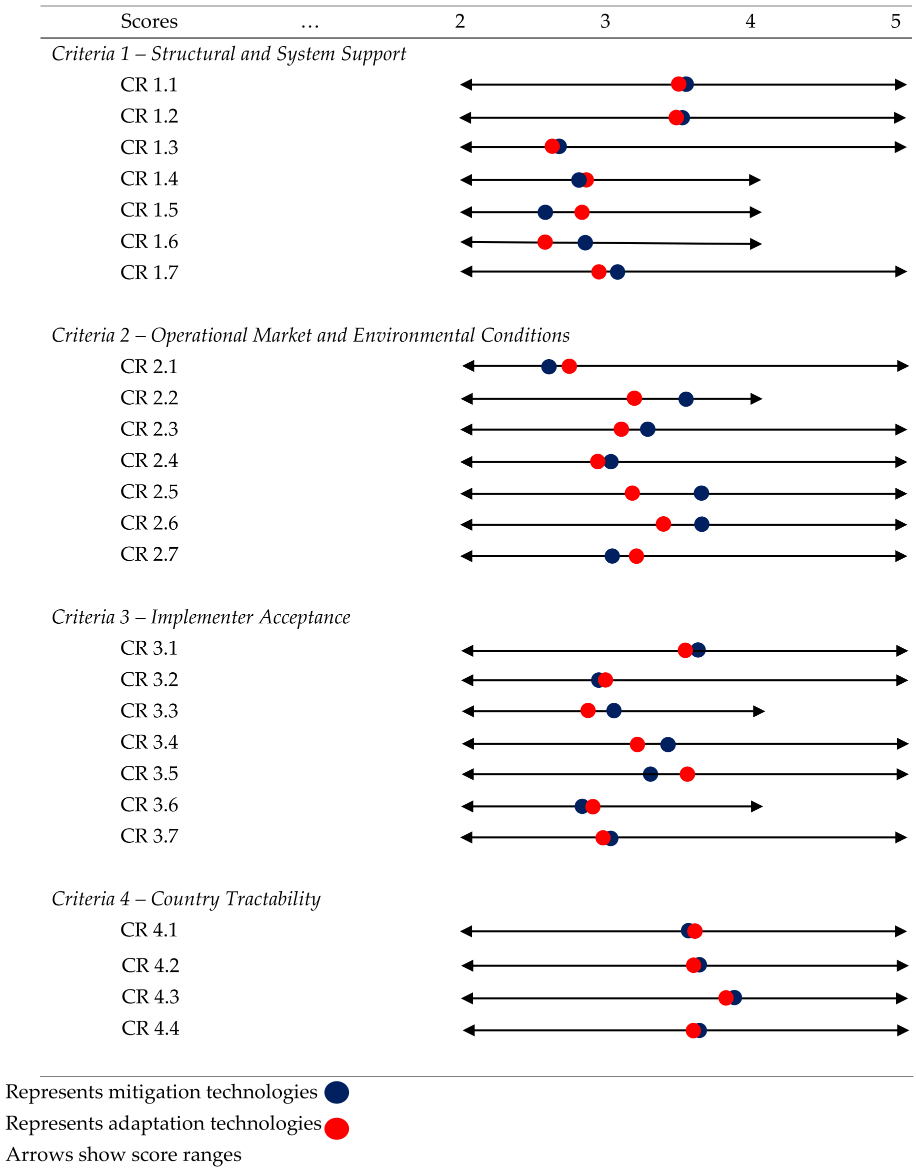

Fig. 2 Aggregated diagnostic tool institutional scores for all countries

Climate change adaptation projects (for example, agriculture) are also not well aligned into national goals putting less emphasis on those projects.

Operational markets and environmental conditions are very weak in Seychelles: This points to deficiencies in existing market mechanisms, government incentives for clean technologies, and licenses for companies to operate. Evidence of this includes the absence of financial incentives in the form of subsidies to promote the low-carbon

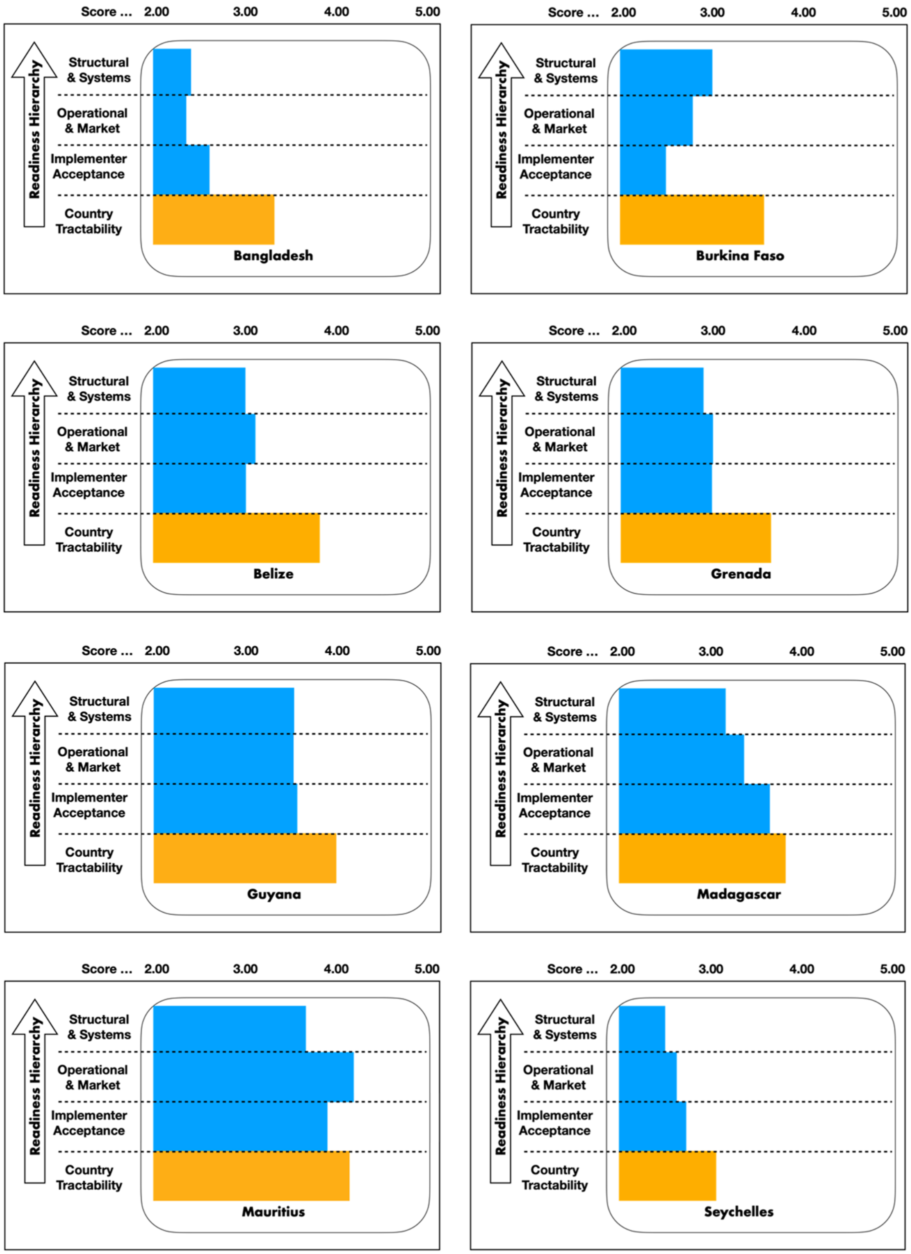

Fig. 3 Graphical representation of country assessment by main diagnostic criteria on a scale with 1–5

motorized vehicles for their transportation project listed in their TNA, high capital costs of some large-scale energy project that makes it more difficult for the country to secure finance, especially when their economic base is constraint. This applies equally for their adaptation projects where high upfront costs are difficult to secure.

Implementer acceptance is very weak in Grenada: This points to deficiencies in social norms and behaviors that make technology implementation difficult; negative perceptions about new technologies and cultural values that reduce user's acceptance of the technologies. Evidence of this includes Grenadian's unacceptability to drink desalinated water which jeopardizes their adaptation project; they are also resistant against using biogas for cooking purposes—a project that their government is trying to push through their TNAs—which is commercially unattractive with LPG as alternative.

Country tractability is very weak in Bangladesh. This points to deficiencies in the country's inter-organizational and intra-organizational coordination and organization for improving technology readiness. It can also point to the country not being interested in or prioritizing technology solutions at this present time. Evidence of this includes a lack of collaboration and networking among organizations and less scope for participation of different institutional actors, especially in their adaptation projects. For mitigation, Bangladesh has been prioritizing natural gas and coal-based technology which indicates that the country might be looking for something else through their TNA recommendations.

(2) *Country with "strong" institutional regimes*

Guyana seems to be reasonably strong across all criteria. Pointing to strengths in institutional rules, legal environment, regulatory environment, and political environment related to technology implementation. Evidence of this includes commitments in recent years made by the government to launch a specialized Office of Climate Change under the Ministry of the Presidency and restructure the Department of Environment to focus on meeting national environmental quality targets. This also points to strengths in existing market mechanisms or those being considered government incentives for clean technologies and licenses to operate. Evidence of this includes the institution of a very large REDD + and "payment for ecosystem service systems" with multiple international agency partners and countries to preserve the country's natural forest cover. This point also illustrates strengths in social norms and behaviors that make technology implementation easier and positive perceptions about new technologies and/or certain cultural values that increase users' acceptance of the technologies. Evidence of this includes more engagement with the government on climate change issues by organizing business interests such as the newly formed Guyana—US Chamber of Commerce and others. This points to strengths in the country's inter-organizational and intra-organizational coordination and organization for improving technology readiness. It can also point to the country not prioritizing technology solutions at this present time. Evidence of this includes the government's increasing welcoming to renewable energy technology investors including recently from the United Arab Emirates, Germany, and others that have assessed positive conditions in the country.

(3) Identify "clusters" of countries that have similar institutional profiles, hence creating peer groups that can work to improve together

In the set of LDCs–SIDS assessed here, there appear to be four sub-groups or "clusters" of countries exhibiting some similarities in institutional profiles. One cluster includes Grenada and Belize. Both countries exhibit relatively similar levels of institutional development within each of the diagnostic criteria. This suggests that when we dig into the institutional engine to make institutional improvements, we should see some levels of coordination or complementarities that are eliciting this diagnostic result. It is likely that the inter- and intra-organizational structures of these countries, their regulatory and policy arrangements, markets and market operations, and social norms and behaviors are working with some amount of complementarity. Having identified these two countries as having this institutional condition, there could be bilateral efforts to learn from each other's institutional efforts to make improvements.

A second cluster of countries includes Seychelles and Mauritius where our diagnostic suggests greater institutional strength on country tractability and implementer acceptance levels, less so on markets and market operations and least at structural and systems level. Again, this means that this grouping of countries may be experiencing similarities in institutional engine components and can work together to share experiences and find solutions that may serve each of their common institutional conditions. Interestingly, unlike any of the other country clusters that seem to be emerging, this cluster is also geographical in nature perhaps pointing to some foundational or historical commonalities in the evolution of the country's institutional environments. It is well established in the literature that countries which are neighbors have common policies or programs due to a process of "learning." Decision-makers tend to seek solutions to their problems by purposive search, and when they do not have all the resources to analyze solutions, they resort to learning from neighbors. One country can thus learn from its neighbor how a technological solution can help solve a climate problem which explains a relatively higher *country tractability* among this cluster (Weyland 2004). Learning can also occur among residents where a technological solution in one country influences the opinions of residents of another country which in turn presses their decision-makers to look for the same solution. This explains the alignment in terms of implementer acceptance among neighboring countries.

A third cluster of Burkina Faso, Madagascar, and Guyana is not as obvious and really highlights why this institutional paradigm approach is relevant. Both of these countries characterized as having institutional commonalities are far from visibly obvious. But they both exhibit very strong implementer acceptance, good operational and market institutional conditions, and relatively weaker structural institutions and systems. Madagascar's strong implementer acceptance much like Guyana could be an outcome of significant efforts at rainforest and biodiversity conservation in the last several decades, now more and more also framed in climate ecosystem service and adaptation terms. But in these countries, intervention is needed to strengthen institutional structures that have evolved weakly, perhaps in part because they both have drastic political regime changes with cautious views of international development interventions in the last decades.

6 Conclusions

The urgency with which developing countries need to adopt climate technologies to reduce carbon emissions and build adaptive capacities is well documented. However, it is also well documented that implementation faces many barriers. Literature suggests the usual suspects of lack of finance and local expertise, but these do not seem sufficient to explain poor technology implementation. This study presents an alternative, if not, additional way to view the situation through institutional lens. It develops and pilots an institutional profiling approach as a means of focusing on institutional issues as the foundational consideration dictating whether technology implementation will be successful or not. When applied to a sample of LDCs–SIDS that have recently updated

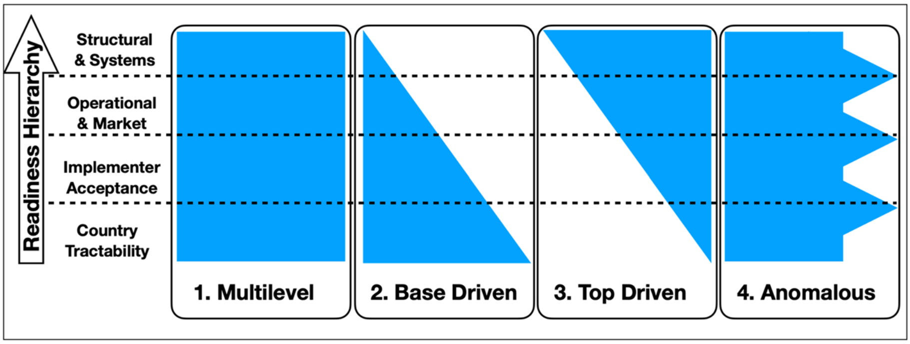

Fig. 4 Institutional archetypes of technology implementation readiness

their periodic TNA reports, we provide some evidence of how this approach works and adds valuable insights for technology deployment and provide some interesting insights in selected LDCs–SIDS. In the interpretation of the results, one unique insight is that several countries' institutional readiness for technology implementation may resemble each other. Clusters of countries that look similar institutionally emerge. We could refer to these as institutional archetypes. Countries that cluster together in the same institutional characteristics could form the basis for working groups to improve the institutional environment leading to potentially more successful technology implementation among them. These archetypes that emerge could look as follows in Fig. 4:

In the Multilevel archetype, the institutional environment of the country is relatively the same or equivalent at all four criteria levels. Here, all four "sub-systems" of the institutional ecosystem are equitably influential. In the Base Driven archetype, there is greatest readiness at the country tractability level and least readiness at the top of the hierarchical arrangement at the structural and systems support level. Here, well-developed and coordinated institutional structure and organization between key actors drive readiness more than the other sub-systems. The Top Driven archetype is the opposite of the Base Driven archetype, with the strongest Structural and System Support and the weakest country tractability. The fourth archetype is Anomalous, meaning that the country does not generally conform to any of the other three archetypes. Here, specificities in any of the institutional ecosystem may be driving readiness. Countries conceivably fall into one of these archetype patterns in response to the institutional ecosystem dynamics that exist in that society.

Owing to the nascent literature on technology implementation, this article presents a new way of looking at technology transferred to countries by demarcating it from technology diffusion. Technology implementation has often been subsumed within the broader topic of technology diffusion which has resulted in poor deployment of the technology in many countries. This article sheds light on technology implementation as an independent yet complementary topic in the area of technology diffusion and transfer. The article contributes to the literature by integrating aspects from different disciplines to develop a holistic framework to understand the enabling environment for technology implementation in LDCs–SIDS and equally provides a way to assess it. Far from being typological, the framework offers practical insights on areas that vulnerable developing countries can concentrate on in their attempts to efficiently implement climate technologies. This can potentially lead to a better distribution of resources and direct targeting of those aspects where more improvements are needed for effective technology implementation. With the observed archetypes, the framework accommodates for possible collaboration among countries to effectively deploy climate technologies.

The framework however has some caveats that should be highlighted and also serve as a basis for future research in this area. At this point, the framework can vouch for LDCs–SIDS but how applicable it is for other countries outside of this category is questionable. Moving forward from this initial framework, the next step might be to test the framework in a more practical sense by using one country as case study and looking at how reinforcing identified weak parts of the framework for one country changes lead to potentially better chances of technology to integrate smoothly into the national technological systems on a country. Such endeavors include looking at how a combination of climate policies to strengthen the operating market and environmental conditions can promote private sector participation in that country, or how some key awareness projects can dismantle myths and distrust over technologies and foster more acceptability.

Lastly, it must be noted that even as this study reveals similarities in national institutional archetypes that will likely indicate that technology implementation success could follow similar pathways across clusters of countries, this alone may not predict implementation success. Indeed, much literature on technology and society suggests that technology implementation is very socially constructed (Bijker et al. 2012; Bijker 2010). So, while we tackle deep institutional character here, implementation pathways can still be variable based on “shallower” and even transient institutional factors (e.g., views of elected officials change in cyclical elections, but the institution foundation of stable democratic elections remains). Further studies can therefore incorporate a conceptualization of the role of more malleable institutional factors as precursors of implementation success. An enhanced or modified diagnostic tool sensitive to processes of the social construction of technology will be an advancement.

Declarations

Competing interests The author declare no competing interests.

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