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Private-sector action in adaptation: Perspectives on the role of micro, small and medium size enterprises

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Private-sector action in adaptation: Perspectives on the role of micro, small and medium size enterprises

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Foreword

John Christensen
UNEP DTU Partnership

The Paris Agreement has set ambitious targets for international climate action and there is a need to identify mechanisms through which private sector actors can be engaged in both adaptation and mitigation efforts – especially in developing countries. The focus here is on adaptation and resilience and if engaged properly, the private sector is in a unique position to develop locally relevant and effective adaptation solutions, which can increase the resilience of businesses and societies.

Although many efforts are underway on the part of various actors to advance the understanding of how to do this in practice, there are still limited understanding and experiences with many remaining uncertainties about how to engage most effectively. The focus of this new publication in the *UDP Perspectives* series is one such area: the micro, small and medium enterprises (MSMEs), which are the backbone of developing country economies. MSMEs play a vital role in providing employment, goods and services and are often hubs of entrepreneurship and innovation in developing countries. As a result of the increasing number of extreme weather events the world is now experiencing, it is often the MSME sector, particularly informal MSMEs, that is hit the hardest, while also having limited access to support mechanisms.

This new volume draws particular attention to the needs, current state of knowledge, critical gaps and mechanisms through which we can build the capacity of MSMEs in developing countries so that they can adapt to climate change and contribute to the creation of climate resilient pathways. Clearly, the business case for adaptation will require levels of commitment and resources that go beyond the MSME sector. The current publication therefore provides valuable insights into how diverse actors working at various levels can support MSMEs in their efforts to ensure business continuity. In addition, it is important for MSMEs to take advantage of the new opportunities that may arise from climate change and translate these into building resilient local economies. Doing so will require a harmonization of effort across various global to local development initiatives, such as National Adaptation Programs, to avoid maladaptation.

We hope this publication will provide some momentum in creating dialogue and in generating innovative ideas and tangible actions that can pave the way to the promotion and incentivization of MSME adaptation in developing countries.

John Christensen

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Caroline Schaer
UNEP DTU Partnership

EDITORIAL

Private-sector action in adaptation: Perspectives on the role of micro, small and medium size enterprises

1. Background and objectives

The UNEP DTU Partnership (UDP) 'Perspectives' Series is a series of publications produced by UDP to share expert and practitioners' opinions and experiences on emerging topics related to climate change. This latest volume shares diverse and original perspectives, insights and reflections on the role and prospects for the private sector to build climate change resilience. It focuses especially on the perspectives of micro-, small and medium-size enterprises (MSMEs) in developing countries, which are particularly vulnerable to climate change, and presents thirteen individual articles from a wide range of experts and practitioners dedicated to this emerging but growing area of work.

The existing literature and knowledge on private-sector engagement in adaptation is a relatively underdeveloped field, empirical evidence for it being sparse, especially with regard to MSMEs in developing countries. Thus far, MSME activity on climate change has been focused primarily on mitigation. With respect to the contribution of the private sector to adaptation, this is typically seen as one of financing adaptation, rather than of driving and guiding adaptation efforts. Moreover, differentiation is rarely made between the different actors within the private sector, such as multinationals, MSMEs or financial institutions. To date, therefore, the literature on private-sector engagement only

covers a fraction of the global private sector. This publication seeks to address these gaps and shortcomings by exploring the diverse perspectives and scope for enabling MSMEs to minimize the negative effects of climate change and to harness some of the positive consequences and potential business opportunities that exist in this area.

A further aim of this publication is to lay the groundwork for a greater focus on one particular group of businesses, MSMEs, in the area of adaptation and to encourage greater international attention and debate regarding their particular needs. By gathering insights and experience from leading experts from different fields and backgrounds, the aspiration of this volume is thus to kick-start consideration of this topic and anchor it at the academic, political and practical levels in order to reach beyond the usual siloed thinking that is characteristic of this area of research.

The perspectives and discussions provided by the articles in this publication therefore seek to contribute to:

- an increased understanding of the rationale and business case for MSME actions in the context of climate change adaptation;
- learning from existing approaches, as well as the barriers, incentives and opportunities involved in catalysing the engagement of MSMEs in developing countries in adaptation efforts;
- exploring the potential for specific instruments and mechanisms conducive to triggering MSME actions and investments in adaptation;
- providing future directions to support and scale up MSME engagement in adaptation.

The following section starts with a brief description of the scope of the publication and the MSME terminology used within it. Subsequently, the relevance of an MSME focus and understanding of their role as adaptation actors is presented. Then, the rationale for MSMEs' engagement in adaptation and some of the key barriers and challenges they face are outlined. Drawing on the articles, key recommendations for how MSMEs' adaptation actions may be enabled are set out in the final section.

2. MSME engagement in adaptation: a note on scope and terminology

Private-sector adaptation initiatives may relate to enterprises which (a) protect their own interests by climate-proofing their value chains and business operations; and (b) innovate and provide products and services in response to a market need in support of adaptation efforts in vulnerable communities. The focus of this publication is on the potential for engaging micro-, small and medium-size enterprises (MSMEs) in climate adaptation, which includes formal and informal enterprises in urban, peri-urban and rural areas in developing countries. While the focus is on climate adaptation and developing countries, examples from developed countries and the parallel track of climate mitigation are integrated throughout the volume whenever their lessons contribute to advancing knowledge on the former topics. Although 'MSME' is the term used here, small and medium size enterprises (SMEs) are also referred to in certain cases (sometimes interchangeably with 'MSME') when, for example, specific programmes, projects or policies have used this term instead to target specific enterprises.

In the publication, we initially use the IFC's definition of MSMEs as: 'micro enterprises: 1–9 employees; small: 10–49 employees; and medium: 50–249 employees' (Kushnir, Mirmulstein, and Ramalho, 2010). However, it is important to note that the technical definition of MSMEs, in terms of number of employees, assets and sales, will typically vary from country to country. A medium-size enterprise in one country may therefore be defined as small in another. Generic definitions are therefore sometimes inconsistent with the realities on the ground, and local definitions should take precedence.

In addition, we should be mindful of the fact that, since MSMEs are not a homogenous group, it may sometimes be counterproductive to group a highly heterogeneous group of firms by size alone. In addition to an extensive range of different sizes, MSMEs comprise businesses from distinct sectors, with very different managerial and technical capacities, resource endowments etc. However, while this should certainly be kept in mind, it remains relevant to consider them as a group, as they also share many commonalities. An important consideration is that informal MSMEs often outnumber formal MSMEs in developing countries and are typically not recorded in official statistics.

3. Including MSMEs in adaptation efforts: a timely focus

Traditionally the planning, financing and implementation of climate change adaptation measures were viewed as the responsibility of the public sector alone. With global estimates showing that the costs of adaptation in developing

countries will considerably exceed the public sector's financial resources (rising to US$ 500 billion by 2050 (UNEP, 2016)), involving private actors and coordinating public and private actions are considered key to building climate-resilient societies in the face of climate change (Dougherty-Choux, Terpstra, Kurukulasuriya, & Kammila, 2015).

Discussion of the significance and prospects for the private sector to contribute to climate change adaptation is thus gaining momentum on the global climate agenda, and there is broad consensus on the potential for increasing private-sector engagement in adaptation. Many of the challenges and opportunities related to private sector engagement in adaptation are inextricably linked to general development challenges and thus will require a synergetic approach. While the private sector traditionally received very little attention in, for example, the National Adaptation Programmes of Action (NAPAs) (Pauw & Pegels, 2013), some international frameworks, such as the Sendai Framework on Disaster Risk Reduction, now explicitly highlight the need to build the resilience of the MSME sector to natural disasters. Resilient and productive MSMEs also have a key role to play in contributing to the realization of many of the UN Sustainable Development Goals. Similarly, regional bodies such as the Asia-Pacific Economic Cooperation (APEC) are undertaking initiatives that support the business continuity planning of MSMEs. The recent inclusion of MSME actions in the Adaptation Fund Portfolio and GEF commitments to support adaptation action in the private sector (described in section B.2) are other examples of the relevance of targeting this group of businesses receiving increased recognition. With its capacity to innovate and produce new technologies, its unique expertise, its financial leverage and its role in scaling up adaptation by communities, as well as in managing risk information, harnessing the private sector's potential will thus be critical if global adaptation goals are to be achieved (Frey et al., 2015).

While there is wide agreement that private-sector financing will be vital in achieving global adaptation goals, surprisingly little is known about how this can be achieved in practice. Although enterprises are increasingly initiating mitigation measures (e.g. improving energy efficiency), they fail to see climate risks and adaptation as business as usual. Some, typically bigger businesses are starting to develop strategies for reducing and managing climate risks, for example, by climate-proofing their supply chains and developing goods and services of use in climate adaptation or disaster response (e.g. water-efficient technologies, drought-resistant seeds, insurance products). However, this is more the exception than the rule, as most businesses are instead adopting a 'wait-and-see' approach, which may be a reflection of their short-term planning horizons.

Existing literature has mainly concentrated on mitigation actions of companies, while failing to pay sufficient attention to their adaptation strategies. Studies of corporate adaptation have started to emerge in the last ten years,[1] but these are largely limited to multinational corporations (MNCs) and mostly focus on developed countries. In the context of adaptation, until recently the term 'private sector' has therefore been synonymous with MNCs, private investors, and their contribution to closing the gap in adaptation finance. Beyond sector-specific or firm-specific studies, the literature mainly presents broad conceptual insights and general recommendations, only going so far as to emphasize the gap between the need to improve MSMEs' resilience and existing knowledge on the issue. Domestic private engagement in adaptation is thus not well documented, especially for developing countries (Pauw & Pegels, 2013). There is also only a limited amount of cross-disciplinary work involving business and climate resilience scholars (Linnenluecke, Griffiths, & Winn, 2013).

In this volume, **Linnenluecke and Smith** review the available evidence for MSME adaptation to climate change (see section A.1). Among other things, they conclude that, although there is a small body of evidence regarding MSME involvement in adaptation, there is a lack of knowledge on the specific drivers, barriers and outcomes of their adaptation efforts, as well as on the suitability of different adaptation options.

4. The rationale for MSME engagement in adaptation

MSMEs are increasingly exposed to disasters resulting of global climate change, which is expected to exacerbate climate impacts such as floods, droughts, sea-level rises, heat waves and storm surges. In addition to extreme events, longer-term incremental climatic changes, such as changing precipitation and temperature patterns, will also affect MSMEs both directly and indirectly by impacting on

[1] See, for example, Agrawala, Carraro, Kingsmill, Lanzi, & Prudent-richard, 2011; Linnenluecke, Griffiths, & Winn, 2012; Pinkse & Kolk, 2012; Haigh & Griffiths, 2012; UNISDR, 2013; Dougherty-Choux, Terpstra, Kurukulasuriya, & Kammila, 2015; Crick et al., 2016; Surminski, 2013; Fry, 2013; Atteridge, 2011; Schneider, 2014; Vivid Economics, 2015.

natural resources, water availability etc. Constituting more than 90% of all businesses, MSMEs represent the backbone of the economy in developing countries (Hussain, Farooq, & Akhtar, 2012) and are very closely integrated into local communities. They contribute significantly to employment generation and supporting livelihoods and are thus key to alleviating poverty and risks to livelihoods from climate change. MSMEs also have an important role to play in global value chains. Subsequently, ensuring their business continuity is critical to minimizing negative impacts on their own operations and domestic knock-on effects, as well as preventing the disruption of global value chains and markets. However, MSMEs have lower technical and financial capacities to respond to climate and disaster risks and are therefore disproportionately more vulnerable to the effects of climate change. They are also particularly exposed because of the very local scale at which they operate in contrast to, for example, MNCs, which operate at much larger scales and can therefore more easily spread their risks. Moreover, a large percentage of MSMEs operate in the informal sector, with very limited access to finance, new market opportunities or public-sector services (Crick et al., 2016).

As a result, MSMEs face a number of direct and indirect risks, which are increasing due to climate change and have wide-ranging adverse impacts. The specific types of exposure and vulnerability of MSMEs are context-specific and will depend on a number of factors, such as the sector in which they operate, the size and location of the business, as well as their policy and regulatory environments. Extreme events can close down MSMEs permanently, or lead them into high levels of debt in order to recover from climate damage to business assets and property. Gradual changes in precipitation and temperature patterns can result in certain crops becoming unviable in some locations and forcing smallholders to adopt alternative livelihoods. A survey conducted by UNEP and the global insurance firm AXA, indicates that the most important climate change impacts felt by SMEs in developed and emerging markets are the rising costs of inputs and insurance and the health and/or well-being of employees. Other negative impacts are reported on production processes, the demand for businesses' products and services, transport, access to markets and the fabric of buildings (AXA & UNEP, 2015). Climate change is also found to affect employee absenteeism, business competitiveness and productivity, production and supply chain movements, and access to raw materials. Moreover, climate change also presents risks to MSMEs from employee migration and knock-on effects such as damage to infrastructure, civil unrest and conflict over increasingly scarce resources such as water. Other indirect impacts include rising insurance premiums and tighter regulation (Berkhout, Hertin, & Arnell, 2004). Beyond the direct effects of climate change on MSMEs themselves, their lack of capacity to counteract these effects have far-reaching impacts on communities by increasing local unemployment and decreasing wealth, thus creating or exacerbating socioeconomic problems in the community in general.

Given the lack of capacity on the part of the public sector in many developing countries to provide adequate risk-management services and adaptation planning, it is essential that local businesses make individual adaptation efforts to complement government support. There is thus a strong rationale for private actors, irrespective of their size, to engage in adaptation and to consider resilience-building as part of their business continuity planning. However, individual adaptation measures applied by private actors in an uncoordinated manner, without the involvement of the public sector, may be directly harmful and lead to maladaptation in the long term. Building the capacity of MSMEs to deal with climate risks and to engage in disaster risk management and adaptation in an appropriate manner, is therefore key to ensuring business continuity and building the resilience of vulnerable communities. By understanding the risks that climate change present to their businesses and by investing in adaptation, MSME actors will not only 'climate-proof' their business operations, they can also be instrumental in creating new economic opportunities and minimizing climate impacts on local economies. A paradigm shift is thus required for businesses to fully integrate the value associated with managing climate risks (Biagini & Miller, 2013).

5. Barriers and challenges to MSME engagement in adaptation

Given the strong case for MSMEs to adapt and play an active role in resilience-building, why is climate change adaptation not yet considered an aspect of business as usual?

First, there is an inherent mismatch between the high level of vulnerability of MSMEs to climate impacts and their own levels of awareness of climate risks and the capacity for adaptation. Awareness among MSMEs of specific climate risks to their business operations and their technical and

financial capacity to counteract them is typically low. Either they do not perceive climate change to be a risk factor in line with, for example, financial instability, or, when they do, they typically have limited access to adequate climate information and expertise to predict and plan risks accurately (AXA & UNEP, 2015). In addition, various cognitive and subjective barriers also influence MSMEs' perceptions about climate change and their own abilities to adapt and take control of business continuity. Changing perceptions, cultural values and norms is therefore a critical component in building MSME resilience (Kuruppu, Mukheibir, & Murta, 2015).

Secondly, a key barrier to MSMEs' engagement in adaptation and resilience-building is that they typically prioritize more pressing and immediate short-term issues and profit-maximization goals and objectives in their business operations (Linnenluecke, Griffiths, & Winn, 2013). As a consequence, they operate with much shorter business planning cycles than larger companies and have limited access to funding for adaptation. As a result, existing responses are often reactive, and a proactive approach to adaptation is unusual for MSMEs, as they often fail to see the incentives they have to become involved in early adaptation planning and to invest in building resilience. Furthermore, the feedback mechanisms demonstrating the benefits of adaptation measures are currently weak (Berkhout, Hertin, & Gann, 2006). This further reinforces the ambiguity of the perceived link between adaptation and business advantages, as the evidence base for private-sector adaptation is very limited. Consequently, in the absence of feedback demonstrating the benefits, coping and adaptation strategies will typically be reactive rather than proactive.

Thirdly, the business case for proactive adaptation is obscured by uncertainty over the location, magnitude and timing of climate risks and impacts. The models used to manage and price risks have so far typically been backward-looking (based on historical data), which makes it difficult for companies to deal with future-oriented uncertainties (Okereke, Wittneben, & Bowen, 2012). Even in cases where climate information is accessible and risk awareness is high, there are few tools available for selecting adequate location and time-specific adaptation measures (Dougherty-Choux, Terpstra, Kurukulasuriya, & Kammila, 2015). This is because it is not possible to generalize the particular risks they face, their adaptation needs and the different adaptation measures they have at their disposal. MSMEs thus have insufficient access to the specific climate data, technology and methods that are relevant for their particular businesses and geographical locations.

Finally, MSMEs lack the necessary external support to plan and adapt to the consequences of climate change. MSMEs have typically limited access to credit, aid and insurance and only a few MSMEs currently engage with national or local government specifically regarding adaptation, as involving the private sector in resilience-building is not yet instinctive for local governments. Although both the public and private sectors would reap these benefits, barriers in understanding each other persist.

Consequently, the barriers and challenges facing MSMEs in responding to climate change are numerous, diverse, and depend on the specific environments and sectors in which they operate. To create effective strategies that build MSMEs' resilience to climate change and extreme weather events, we need a better understanding of the magnitude of the problem and the drivers behind it. The first step in supporting MSMEs to engage in resilience-building is therefore to identify these contextual barriers and the key resources, actors and levels of involvement necessary to overcome them. In section A.2, **Chaudhury** presents a conceptual framework structuring the key barriers to adaptation facing MSMEs in developing countries, by using examples from the agricultural sector; these include: 1) insufficient knowledge about climate risks; 2) inability to evaluate cost-effective adaptation measures; 3) limited financial resources; 4) low technical capacity to implement options; 5) unsupportive policies and regulations; and 6) insufficient social acceptance of adaptation options.

While it is undeniable that MSMEs face significant risks from climate change and that significant barriers have yet to be overcome for them to be engaged actively and effectively, MSMEs are not helpless actors. Findings also demonstrate the inherent agency of MSMEs to take action and change their practises, given the right conditions and supporting environments. For example MSMEs who have adapted after experiencing various extreme climatic events, were found to possess key characteristics that were supportive of adaptive behaviour, including self-organisation capacity, strong social networks and self-efficacy beliefs (Kuruppu, Mukheibir & Murta 2015).

6. Catalysing MSME adaptation

While the need and urgency of finding ways to involve businesses in adaptation efforts, irrespective of their size, and the opportunities that climate change also represent are indisputable, the question that remains is, "How do we make this happen?". While this publication does not provide all the answers, a set of general recommendations and findings can be drawn from the articles presented here. These are outlined below under five key headings, which summarize some of the triggers for MSME adaption actions:

- Demonstrating and scaling up the business case for adaptation
- Democratizing climate data: access to tailored climate data and information
- Using language, tools and financial support mechanisms that are tailored to the local realities confronting MSMEs
- Involving the informal sector and marginalised MSMEs
- Creating strong partnerships and enabling environments to build climate resilience

Demonstrating and scaling up the business case for adaptation

Adapting to the consequences of climate change also offers opportunities beyond resilience. Given the projected global adaptation needs and public actors' limited capacity and resources, combining risk awareness and business development becomes a new way of conceptualizing adaptation and risk management. Interestingly, a survey conducted by AXA and UNEP finds that 53% of businesses in developed and emerging markets believe that climate change represents an opportunity for their businesses (AXA & UNEP, 2015). Often MSMEs are embedded in the local context within which climate action must be taken, and possess a 'social license' to operate which can facilitate the dissemination of vital climate information (Terpstra, McGray, & Ofstedahl, 2013).

In certain cases climate change can thus be considered as a business opportunity for MSMEs rather than as a risk. Concurrently, the robustness of the business case for adaptation action is often limited, as profitability and risk management benefits for businesses are often unclear. **Wilson** describes how the drive to build climate resilience may represent significant opportunities for many businesses in developing countries. Beyond climate proofing, he looks at private innovation in the domain of resilience. Based on emerging lessons from the Proadapt Program, he shows how climate risks are driving a growing demand for private climate-resilience solutions. These solutions include, for example, water-efficient technologies, low-drip and efficient irrigation, wind-, flood- and heat-resilient building materials, flood control, new financial and insurance products, early warning systems, drought-resistant seeds and new health-care products, among many other solutions.

The development of innovative resilience products can maintain MSMEs' viability and create competitive advantages, but it can also create local capacities in resilience, generate livelihoods and contribute to greater public efforts toward adaptation. Consequently, mainstreaming, demonstrating and scaling up climate-resilient business models for value addition and employment throughout value chains is a key priority.

In their article, **Hoedjes, Miller and Usher** describe how climate risks provide an entrepreneurial stimulus to realize new business objectives in the context of weather and climate information (WCI) products and services. They describe how private actors (e.g. mobile telephone providers) are developing innovative business models for WCI products and services targeted at the specific needs of MSMEs. In doing so, they contribute to the development of local adaptation capacities by providing information services that are currently not offered by national meteorological and hydrological service. While some of these are donor-funded, they also find that more and more of these companies are applying sustainable commercial models. Similarly, **Kuruppu, Bee and Schaer** present examples of how MSMEs can build business cases for adaptation in the agricultural sector and adopt innovative technologies that mitigate climate risks while sustaining livelihoods. By drawing on three cases from the ADMIRE project in Ghana, Jamaica and Peru, the authors show how MSMEs can leverage public funding to generate private capital and develop strong business cases for adaptation. These cases demonstrate how the process of MSMEs building a solid business case is critical to accessing lending systems and attracting financial investment opportunities that will support climate adaptation. They also find that 1) technology development and proof of concept, 2) training and institutional support, 3) value-chain mapping, and 4) capital investment are all critical enabling factors supporting business case development.

Democratizing climate data: access to tailored climate data and information

A recurrent recommendation in the articles is that, to accelerate the adaptation dynamic, MSMEs need to be aware of the specific risks they face, as well as the opportunities that may arise with climate change. Greater knowledge is thus needed to help businesses and investors effectively frame both climate-related risks and opportunities if they are to initiate adaptation activities. There is no one-strategy-fits-all model for enterprises in a country or sector. MSMEs should have access to information on context-specific risks and locally designed solutions in a user-friendly, easily accessible format (e.g. in local language), as well as the capacity to comprehend the information if they are to address the climate-related problems they face.

Hoedjes, Miller and Usher explain how effective weather and climate systems are a prerequisite for efforts to strengthen MSMEs' resilience to climate change, and how MSMEs' capacities to adapt will only be unlocked when they have access to timely, accurate, usable and useful weather and climate information. As MSMEs are typically unaware of the specific climate risks and potential for adaptation of their business operations, they need improved access to relevant data and information that are tailored to their needs and contexts, as well as to the scale of their operations. Farmers, for example, need short- to medium-range rainfall forecasts in order to decide when to plant, apply fertilizer and harvest, and where and when to sell produce. Information could also be made available in the form of early warnings in order for businesses to prepare for extreme events and to reduce climate impacts. The problem is that, as providers of weather and climate information (WCI) services, national meteorological and hydrological services (NMHSs) in developing countries rarely have the resources and/or expertise to offer products that are adapted to MSMEs' specific needs and situations. The authors provide examples of successful business models for the delivery of WCI services, where private companies have identified gaps in information services and are providing tailor-made WCI products specifically targeted at the needs of MSME users, sometimes in cooperation with national meteorological actors.

Nagrecha and Chawla present a method to democratize MSMEs' access to climate data: the 'Cambio Score', an open-source, data-driven framework to help private-sector actors identify and prioritize climate-change risks to their business. The objective with the Cambio Score is to enable businesses to identify and prioritize areas of vulnerability and means of readiness in the face of climate change, thereby increasing their awareness and adaptation capacity.

Wilson raises the issue that data on resilience-building products and services are not systematically collected, nor are MSMEs' actions captured as such by public authorities. This means that little is known about the sectors, product groups, emerging technologies and/or strategies that represent the greatest private opportunities for companies and investors. In this sense, he argues that private-sector awareness of climate resilience opportunities is often lower than its awareness of climate-related risks. He finds that a better understanding of the market through improved access to information about resilience initiatives is key to encouraging MSMEs' adaptation efforts and may also add to national resilience efforts in developing countries (for example, by contributing to the efficiency of National Adaptation Plans).

Using language, tools and financial support mechanisms that are tailored to the realities confronting MSMEs

Language and decision-support tools

General awareness of climate change risks alone typically does not translate into adaptation action and/or investments. **Frei-Oldenburg et al.** find that MSMEs need to adopt a language and concepts that appropriately reflect the realities of their businesses. An important insight from several of the articles is that science, donors and businesses often fail to speak the same language. For businesses, adaptation to climate change may be seen as a somewhat artificial concept. They do not use climate terminology to describe their activities, and they do not separate climate and non-climate factors, but rather take into account risks that impact on their operational continuity, business assets and property, supply chains, logistics and other variables affecting their competitiveness. Similarly, private innovation and market activity in respect of climate resilience is rarely labelled as such. Some businesses in vulnerable regions are already investing in adaptation without identifying them as such. Therefore, as **Wilson** argues, presenting adaptation as an additional element of corporate risk management and mainstreaming climate resilience into existing processes in enterprises should become a best practice for navigating climate variability.

In the same line of thinking, tailored decision-making tools are needed to guide adaptation action. **Chaudhury and Linnenluecke and Smith** find that the inability to evaluate cost-effective adaptation measures and a lack of information on the different context-specific options available to MSMEs constitute a key barrier to their engagement in adaptation. In the absence of feedback mechanisms that demonstrate the benefits of adaptation measures, it is often difficult to demonstrate and convince MSMEs of the mutual economic and social benefits of engaging proactively in adaptation.

In response to these needs, **Frei-Oldenburg et al.** presents the Climate Expert approach developed by GIZ for the SME sector, which includes a risk assessment, the identification of suitable adaptation measures, a cost-benefit analysis (CBA) and the development of an adaptation strategy. Based on experiences with the application of the tools in Bangladesh, Costa Rica, Morocco and Rwanda, the authors demonstrate the need for SMEs to perceive their ownership in the adaptation process, in order to strengthen their resilience. The authors find that investment in adaptation is driven by: a) expected reductions of risk, b) reductions in costs, and c) the creation of new opportunities and the expectations of future revenues. They find that SMEs initiate action only when they see distinct business advantages in assessing and managing climate-related risks and opportunities that such tools demonstrate. One of the key messages is that MSMEs are willing to invest in adaptation as long as the business advantages of doing so are sufficiently clear to them. They find that adaptation strategies for SMEs are necessary for ensuring their survival, as well as for supporting their efforts to stay competitive and realize new business opportunities.

Similar findings are presented by **Pantakar et al.** in the context of the participation of SMEs in the planning, financing and implementation of adaptation measures in Mumbai. The authors present an operational and financial framework for SME-funded resilience efforts to cope with the recurrent floods in the city. They find that SMEs are willing to design and implement solutions for flood protection once they are provided with the economic rationale and the right mixture of solutions and guidance in identifying and customizing them. This approach provides a unique opportunity to identify locally designed solutions for local problems, rather than relying on a top-down approach that may not always be appropriate given the specific circumstances and needs of the local users.

Financial support mechanisms

Despite the high levels of climate risk exposure of MSMEs, limited formal financial support mechanisms exist that can be accessed by MSMEs for adaptation. International support to the private sector is unlikely to reach domestic MSMEs, as existing financial instruments and international donors are often more suited to supporting large companies.

Suminski and Hankinson discuss the role of insurance in protecting MSMEs against climate and disaster risks in developing countries. The authors find that insurance can help MSMEs to plan ahead and take positive business risks while transferring disaster risks, but also that most climate-risk insurance schemes focus on the short-term transfer of risks, rather than on building resilience over in the longer term. They find that climate-risk insurance has the potential to support adaptation if it is designed and implemented with risk reduction in mind, with a greater emphasis on capacity-building and risk education that can come from using insurance. As an example, they suggest that risk transfer could provide incentives for MSMEs to implement business continuity plans and that these could even become a precondition for cover, while insurers should also offer support and advice. A similar example is described by **Frei-Oldenburg et al.**, who suggest that climate risk assessments and the presentation of adaptation strategies could be integrated into the general risk assessment of loan-appraisal processes.

Watson and Patel analyse how MSMEs' climate actions and their access to finance is being supported by multilateral climate funds by investigating nine dedicated climate funds, five of which operate as financial mechanisms under the United Nations Framework Convention on Climate Change (UNFCCC). They find that climate action by MSMEs is being supported by the multilateral climate funds in relatively small but increasing volumes. They argue that multilateral climate funds have an important role to play in accelerating and unlocking the potential contribution of MSMEs. Given the limited range of financial products and novel approaches targeted at MSMEs, which lack proven business models, financial institutions will typically be unwilling to lend to MSMEs, and the private sector will be reluctant to invest. Certainly, climate funds are able to withstand a degree of risk that other sources of finance cannot, as they can offer both a source of finance for climate action and a way of piloting and testing financial products and instruments, which may help overcome the high costs and risks associated with

lending to MSMEs. The authors argue that, for multilateral climate change funds, demonstrating and unlocking the opportunities that MSMEs present for adaptation will require more than increased project finance – it will also need a clearer articulation of how the funds will engage MSMEs and develop pro-MSME policies and investment frameworks. They also stress that action by the climate funds must be supplemented by state action that supports MSMEs in taking climate action.

Involving the informal sector and marginalised MSMEs

A key theme that emerges in this volume is that the majority of MSMEs face critical challenges because they often operate in the informal sector. This limits their access to basic infrastructure and public services, including finance and insurance, which makes them extremely vulnerable to climate change impacts. Strengthening adaptation awareness and capacity for MSMEs locally thus not only requires access to relevant data, tailored decision-making tools, a strong enabling environment and/or supporting financial mechanisms. Also required is the development of specific approaches that are tailored to MSMEs in the informal sector.

O'Brien and Brandes–van Dorresteijn, for example, emphasize that including the informal sector in decision-making should be a key consideration for policy-makers, as government action targeting MSMEs will not be effective without taking into account the large percentage of businesses operating outside the formal sector. Thus implementing tax breaks, for example, would not benefit MSMEs in contexts with large informal sectors and weak tax collection systems. The same is true for financial products, as **Watson and Patel** explain: reaching MSMEs in the informal sector with traditional financial products is complex and will require alternative approaches, such as the development of alternative credit-worthiness assessments.

With a methodology developed to target women smallholders, many of whom are found in the informal sector, **Anderson and Marcatto** describe how participatory approaches are key to enabling resilience-building within this group. This method was developed by ActionAid International to reach some of the most vulnerable MSMEs and address the many inequalities and obstacles faced by women smallholders. The approach consists of a series of participatory tools through which women farmers are enabled to analyse their value chains and market opportunities, take action to strengthen their access to markets, and thus improve their adaptive capacity.

Creating strong partnerships and enabling environments to build climate resilience

A crosscutting theme for many articles is that many MSMEs need support in order to be able to act on resilience and adapt over the longer term. The right mixture of incentives, enabling environments and partnerships need to be in place. Partnerships of different kinds with diverse stakeholders are found to be important vehicles for enhancing climate resilience and creating business opportunities. Public–private partnerships on mitigation, for example, have often proved successful, and a lot can be learnt from these experiences when it comes to enabling adaptation partnerships. In several articles, increased partnerships between government and business are recommended in order to enhance the transparency and efficiency of public- and private-sector efforts in this area, for example, supporting the implementation of National Adaptation Plans.

Various authors have emphasized the importance of engaging with non-profit entities and firms of different sizes, including multinational corporations, larger anchor firms functioning as hubs for supply chains composed of MSMEs and intermediary organisations, such as chambers of commerce, business associations etc. **(Frei Oldenburg et al.; Pantakar et al; Wilson; Hoedjes, Miller and Usher)**. To sustain their own businesses, multinational and other large companies would benefit from partnering and investing in making MSMEs within their supply chains more resilient in order to minimize production disruptions. Strong private partners have the resources to create awareness, disseminate best practices and facilitate market access for smaller suppliers.

Pauw and Chan explore the potential of multi-stakeholder partnerships as a vehicle for MSME engagement and consider MSMEs to be a key actor in linking donor countries, multinational corporations and local communities. They find that while multi-stakeholder partnerships may contribute to the implementation of the Paris Agreement, the link between partnerships and intergovernmental processes is often weak. They find that the representation of MSMEs in global multi-stakeholder arrangements and platforms is low and that the emphasis in terms of business

participation remains on the larger businesses. This may indicate that adaptation partnerships are not embedded in the local economy and institutions and therefore do not benefit MSMEs and other local stakeholders. This may also suggest that they are not recorded as such, as limited data and no standard metrics are available for adaptation partnerships. They argue that international and donor organizations, which are leading most recorded adaptation partnerships, should facilitate the involvement of MSMEs in localized partnering processes, by raising awareness of the private and public benefits of community-level adaptation and improving access to financial resources.

Looking at central actors in creating enabling environments for MSMEs', **O'Brien and Brandes–van Dorresteijn** analyse the different instruments that governments have at their disposal to support MSMEs' adaptation actions and investments, with examples from various countries. They find that there is generally a significant gap in policies targeting MSMEs directly. They provide examples of how changes to regulatory regimes and subsidies, including tax relief mechanisms, can be implemented by governments in the form of push and pull drivers to stimulate MSMEs' adaptation actions and also to increase the attractiveness of MSMEs for investors. They argue that an effective enabling environment requires a focus extending beyond MSMEs to target the entire value chain. **Pantakar et al.** also find, in the context of Mumbai, that a policy push from the government is needed to enable private-sector efforts in the form of incentives, for example, the inclusion of flood resilience in building codes, in order to accelerate the adoption of resilience-building measures by the private sector.

7. Overview of articles contained in this volume

All the articles included in the publication are intended as stand-alone pieces. They can be read individually and/or in any order. There is, however, an underlying logic to how the publication has been structured.

Section A starts by framing the topic of the role of MSMEs in adaptation by exploring the ***'current knowledge, barriers and opportunities for engaging MSMEs in resilience building'***. The section starts with **Linnenluecke and Smith**, who present an overview of existing research and gaps in the field, followed by **Chaudhury**, who presents a conceptual framework for understanding the underlying barriers to MSMEs engaging in adaptation. Subsequently, **Wilson** describes how the drive to build climate resilience represents significant opportunities for many businesses in developing countries. Finally, **Kuruppu, Bee and Schaer** explore how business cases for adaptation can be built for MSMEs in the agricultural sector to adopt innovative technologies that mitigate climate risks and sustain livelihoods.

Section B explores the various ***'enabling instruments and mechanisms for promoting MSMEs adaptation action'***. It starts by looking at the role of financial support mechanisms. Thus, **Surminski and Hankinson** explore how insurance may enable MSMEs' engagement in adaptation, while **Watson and Patel** analyse the role of multilateral funds in unlocking climate action. In the following article, **Pauw and Chander** examine the role of MSMEs in multistakeholder partnerships. Following this, **O'Brien and Brandes-van Dorresteijn** analyse and discuss the different instruments that governments have at their disposal to support MSMEs' adaptation actions.

Section C presents different ways of ***'improving access to climate data and decision-support tools tailored to MSMEs'***. In the first article, **Nagrecha and Chawla** present an open-source, data-driven framework developed to help private-sector actors identify and prioritize climate change risks to their businesses: the Cambio Score. In the following article, **Hoedjes, Miller and Usher** reveal how the delivery of weather and climate information (WCI) services may be significantly improved through private-sector provision of tailor-made products. Then **Frei-Oldenburg et al.** show how a bottom-up decision-making tool tailored to MSMEs, called the Climate Expert, can strengthen their adaptation awareness and actions. In the same line of thinking, **Pantakar et al.** present a financial and operational framework developed for MSMEs to design, finance and implement flood-resilience measures in Mumbai. Finally, **Anderson and Marcatto** demonstrate how participatory methods targeting women smallholders can help build the resilience of the most vulnerable MSMEs.

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SECTION A

Current knowledge, barriers and opportunities for engaging MSMEs in resilience building

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Adaptation of MSMEs to climate change: a review of the existing literature

Abstract

This article provides an overview of existing research on the adaptation of Micro Small and Medium size Enterprises (MSMEs) to climate change. The article summarises how existing research has addressed such adaptation with a focus on MSMEs in both developed and developing countries. It also shows how MSMEs have adapted to climate change by summarising case studies from the literature and discussing their implications for both adaptation research and MSMEs. The article outlines the threats and opportunities that climate change represents for MSMEs and discusses the opportunities related to progress in respect of international policies regarding adaptation funding and for MSMEs to engage in adaptation planning.

1. Introduction

The aim of this article is 1) to summarise how existing research has addressed the adaptation of Micro Small and Medium size Enterprises (MSMEs) to climate change; 2) to show how MSMEs have adapted to climate change by summarising case studies from the literature; and 3) to discuss the implications of these case studies for both adaptation research and MSMEs.[1]

Collectively, MSMEs provide the most employment in many low-income countries,[2] yet their contributions to economic growth and social adaptation to future challenges, including climate change have been understudied, presumably due to their lack of economic power and status. Nonetheless, there are strong scientific, economic and development-oriented reasons to include MSMEs in climate change adaptation.

From a scientific point of view, there is an urgent need to address pressing environmental issues, including climate change, biodiversity loss, the over-exploitation of ecosystems and the over-consumption of non-renewable resources, in order to avoid environmental degradation, especially in developing countries (e.g., Rockström et al., 2009, Steffen et al., 2015). Climate change often poses additional stresses in cases where environmental degradation is already taking place (e.g., the further impacts of climate change on freshwater availability and biodiversity loss), thus increasing the need to adapt. In many regions where MSME activities such as small-scale farming or fishing are essential for livelihoods, individuals and communities are directly affected by adverse environmental changes.

The importance of adaptation has been recognized in international policy debates, with the 2015 Paris Agreement making a strong case 'to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty […] by increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production'.[3]

The economic reasons for including MSMEs in climate change adaptation result from the need to strengthen community resilience through private-sector adaptation. Climate change poses many threats to MSMEs (and thus economic activity) in the form of damage to MSMEs' assets, profits and human capital due to rising sea-water levels, extreme weather events, changed river flows and volatile temperatures. Especially in developing countries, MSMEs face significant adaptation challenges due to their limited access to credit, aid, insurance and payment services for purposes of both development and climate change adaptation. Francis & McDonagh (2016) argue that, unless coordinated action is taken on global environmental change, it will be the poorest of the poor who will pay the price for the latter.

Consequently, climate change adaptation is also a development-oriented challenge. However, the available evidence detailing the adaptation challenges and options for MSMEs is sparse. Existing studies suggest that businesses face a number of obstacles in learning how to adapt to climate change impacts, especially due to the lack of clarity regarding how climate change will affect operations and the resulting uncertainties over if and how benefits will flow from adaptation measures (Berkhout, Hertin, & Gann, 2006). This article highlights this important gap by providing a literature review of MSME adaptation to climate change, which points to the distinct lack of adaptation frameworks and debates in the business and management literature, especially for MSMEs in developing countries.

To contribute to the emerging body of literature, we review the available evidence of MSME adaptation to climate change, and highlight and discuss successful examples of such adaptation. While adaptation is particularly pressing in developing countries, we also review literature that provides examples of MSME adaptation in developed countries to provide a fuller understanding of the challenges to MSME adaptation across developing and developed countries. While adaptation is essential to reduce the negative impacts of climate change, innovative MSMEs will be able not just to avoid threats but also to benefit from

[1] The definition of MSMEs varies between countries, but it typically includes companies that do not employ more than a specified number of employees or that do not reach a certain turnover. Among the defining characteristics is often the fact that the owners are actively involved in managing the company, that is, it is highly personalized and often highly local in its area of operation, being small in size in comparison to other companies in the industry (Ebitu, 2016).

[2] See http://www.worldbank.org/en/results/2013/04/05/msme-finance-expanding-opportunities-and-creating-jobs

[3] See http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

innovations and breakthroughs in climate adaptation and mitigation technology that drive economic growth. From a policy perspective, knowledge of the determinants of organizational adaptation is important. Throughout the article, therefore, the opportunities related to the progress with international policy regarding adaptation funding and the opportunities for MSMEs to engage in adaptation planning will be outlined.

2. Background: climate change and MSMEs

Climate change poses threats not just through gradual increases in temperature and also more severe and/or intense weather extremes (Noble et al., 2014). This raises a large number of adaptation challenges for MSMEs. For example, rising temperatures may mean that traditional fishing grounds are no longer viable, necessitating a relocation of fishing activities. More frequent and damaging storms might mean a decline in tourism activity. Rising sea levels and coral bleaching will have adverse impacts on coastal communities. Climate change will also put additional pressures on already degraded terrestrial, freshwater and marine ecosystems, creating challenges for MSMEs that are highly dependent on natural resources.

The possible severity of the consequences of climate change has been outlined by Gubernot, Anderson, & Hunting (2015). The authors point out that, even in developed countries such as the USA, heat-related deaths are more pronounced in industries that are more likely to be dominated by MSMEs, such as agriculture and construction. Hence a review of the literature relating to MSMEs is long overdue. In addition, it is important to realize that MSMEs will be impacted not just by environmental change, but also by political, economic, social and technological changes (Linnenluecke, Smith, & Mcknight, 2016), thus facing additional adaptation challenges.

3. Literature review

A comprehensive search for the available evidence on MSME adaptation to climate change revealed 24 peer-reviewed studies on climate change and adaptation by MSMEs published between 2008 and 2017, as well as several reports from agencies such as the United Nations Development Programme (UNDP), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the World Resources Institute (WRI) (Dougherty-Choux, Terpstra, Kammila, & Kurukulasuriya, 2015). A review of these studies (discussed in further detail in the following section) shows that they address the following major themes: motivations for adaptation efforts; climate change education and awareness; governance; relocation; and case evidence.[4]

Motivations for adaptation efforts

A first major theme in the existing literature on climate change and adaptation by MSMEs concerns the motivations inducing MSMEs to adapt. Revell, Stokes, & Chen (2010) conducted a cross-sector survey of 220 UK SMEs and conclude that it is not only the push of regulatory requirements that motivates small business owner-managers to take action, but also the pull of cost savings, new customers, higher staff retention and good publicity. Lewis, Cassells, & Roxas (2015) argues that collaboration with other firms and organizations can have a profound effect on the success of adaptation efforts. In the context of New Zealand, the authors find that collaborative relationships provide opportunities for SMEs to overcome some of the barriers to implementing environmental initiatives associated with their size and individual characteristics (see also Johnson, 2015). Sampaio, Thomas, & Font (2012) add that certification schemes, with their rigid plan/do/check/review systems, are not suited to MSMEs. Sampaio et al. (2012) concluded that such schemes are more likely to succeed if they take account of management approaches that are specific to the MSMEs, highlighting the need to develop approaches and tools that are not only suited for large organizations.

In the developing country context, Khattri, Parameshwar, & Pellech (2010) propose that there is a strong role for private-sector engagement in supporting social adaptation and assisting with building resilience to climate change in urban areas. The authors propose that there are opportunities in the areas of micro-insurance products that cover life, health, assets and crops; adaptation options in water management; off-grid energy solutions; affordable housing solutions for relocation; and the development of appropriate early warning systems and insurance products. The authors argue that private enterprises can fill important adaptation gaps, as they are incentivised by market forces to offer products or services that are not readily offered by government bodies or not-for-profit organizations.

[4] We used the Social Sciences Citation Index to search the literature systematically in order to identify relevant research on adaptation to climate change by MSMEs. The Index is a large online database containing bibliographic and citation information from over 3,000 journals. To retrieve papers relevant to this study, we searched the title, abstract and keywords of published papers using keywords such as 'climate change' AND 'small business*', 'climate change' AND SME, 'climate change' AND MSME.

Druce, Moslener, Gruening, Pauw, & Connell (2016) highlight the importance of adaptation funding in achieving the challenge of social adaptation and point to actors across four categories: (i) public policy-makers (both nationally and internationally); (ii) providers of public finance (e.g., national, bilateral and multilateral banks and funds); (iii) private financiers; and (iv) private enterprises in the real economy, who constitute the demand side. The authors reviewed evidence from 28 private enterprises and concluded that substantial investments are already being undertaken to foster adaptation and resilience, some of which are bringing significant economic advantages through the development of new adaptation technologies or solutions (e.g., new crop varieties, new financial products or new early warning technologies).

Climate change education and awareness

A second major theme concerns climate change education and awareness among MSME owner-mangers. Williams & Schaefer (2013) studied the managers of small businesses in eastern England and found that their engagement with climate change mainly depends on their personal beliefs and values, and not only on a business case or cost minimization arguments. Focusing on developing countries, Soubihia & Jabbou (2010) examined training needs regarding climate change topics in MSMEs in Brazil using a mail survey, which showed widespread interest in education on climate change and sustainable development. Chowdhury et al. (2016) undertook a case study of organized community participation in education regarding climate change and adaptation in India's Sundarban coastal communities, among the most vulnerable in the world to climate change. The authors concluded that participatory methods of communication, along with the development of adaptation strategies, could be an effective solution to combat climate change problems in a practical manner. North (2015) argues that separate fields such as Polanyian economic geography (an opposition to traditional economic thought which emphasizes that economies are embedded in society and culture) and diverse economic perspectives can be drawn together to aid the implementation of adaptation actions, including environmental actions, corporate social responsibility and low carbon transitions by SMEs. In addition to these findings, a UNDP report (Dougherty-Choux et al., 2015) further identifies education and climate knowledge, as well as access to the appropriate management tools, as two of the major barriers to climate change adaptation. Dougherty-Choux et al. (2015) point out that MSMEs in developed countries have lower awareness of climate risks than do larger companies and emphasize that this lack of knowledge is likely to be even more pronounced in developing countries.

Governance

A third major theme concerns governance structures that facilitate action on climate change by MSMEs. De Oliveira & Jabbour (2015) examine the role that local industry clusters play in influencing SMEs in developing countries to act on issues such as climate change, environmental management and Corporate Social Responsibility (CSR). They put forward an analytical framework that emphasizes the importance of three basic types of cluster governance for improving cluster-based MSMEs: legal enforcement, supply chain pressure and voluntary engagement in CSR. Nejati, Amran, & Hazlina Ahmad (2014) use a survey design of 110 Malaysian MSMEs to find that of all stakeholders, employees and customers influence action on environmental practices the most. Li (2013) examines urban climate change adaptation in China, finding, after reviewing the literature and examining government responses, that the Chinese system limits residents' and small businesses' influence on climate change adaptation due to its focus on growth, lack of provision for participation in decision-making, and weak post-implementation evaluation once a policy has been scaled up nationally.

In addition to these findings, Burch, Schroeder, Rayner, & Wilson (2013) examine an innovative approach in the form of a multisector and multilevel network that links together the regional authority Metro Vancouver in British Columbia (Canada), several municipal governments, a social enterprise and a large number of small and medium-sized enterprises to act on climate change. Burch et al. (2013) find that, although complementarity of actions across levels and sectors is not always achieved, it is likely to contribute significantly to action on climate change. Dougherty-Choux et al. (2015) pick up on the theme of multilevel networks and partnerships to argue that a cost-effective way for MSMEs to overcome their limited resources is to collaborate with other businesses or public entities to form partnerships and cooperatives in a similar sector or region, to pool resources and funding, and to self-insure against economic and weather-related shocks.

Relocation

Loebach (2016) examines relocation in the wake of Hurricane Mitch in Nicaragua. Findings from the study show that the hurricane is associated with a decreased likelihood of relocation from households that own businesses, which can be interpreted as an 'all hands on deck' mentality to assist with business recovery. Linnenluecke, Stathakis, & Griffiths (2011) argue that climate change will lead to significant disruptions to firms, which might ultimately create a need to relocate away from regions highly affected by climate change. This will become necessary due first, to direct disruptions through climate change impacts on firm operations, for instance, through droughts, floods or rises in sea level, and secondly, disruptions in a firm's supplier, buyer or resource base that lead to flow-on effects and adverse consequences for the firm. Linnenluecke et al. (2011) propose a framework for integrating firms' relocation decisions into their adaptive responses to climate change. Three steps are involved in the framework: the level of risk from climate change impacts at a firm's location, the feasibility of relocation, and the associated costs and benefits. Both studies voice concern about the likelihood that extreme environmental events may influence movements of households and business activities, and they both point to the urgent need for future research on this topic.

Case studies of adaptation

The existing literature offers a number of case studies of adaptation by SMEs and MSMEs. Ingirige, Wedawatta, & Amaratunga (2010) examine the exposure of supply chains in the UK construction industry to extreme weather events, which is of importance because nearly all construction sector businesses are SMEs. The authors present a synthesis model that conceptualizes the factors that enhance the resilience of SMEs and their supply chains to extreme weather events. Adding to this line of enquiry, Wedawatta & Ingirige (2012) conduct a case study of flood risk in the UK focusing on SMEs, finding that the latter are likely to respond positively to property-level adaptation in the aftermath of flooding. However, barriers to adaptation and preparedness include a lack of knowledge about information such as costs/benefits and the different options available for SMEs affected by a flood event. Similarly, Catarino, Henriques, & Egreja (2015) point out that SMEs generally suffer from a lack of knowledge, as well as of organizational, training/behavioural, economic and financial capabilities.

Other evidence has been collected in Scandinavian countries. Kaján, Tervo-Kankare, & Saarinen (2015) provide a case study of adaptation to climate change in tourism in Finnish Lapland and based on a survey of seventy local entrepreneurs. They identify five main results: large investments decrease the flexibility to respond to changes quickly; small businesses seem to be most affected in terms of the financial costs; strong seasonality affects the ability to absorb costs; costs could be decreased with effective mitigation; and the benefits can be as significant as the costs. Rauken & Kelman (2012) conducted a case study of the influence of climate change on tourism SMEs in northern Norway. Although the SMEs reported that they were highly dependent on the weather, climate change was seen as only an indirect influence. Thus Rauken & Kelman (2012) reveal a gap between the actual impacts of weather and climate change on the SMEs and their perceptions of the impacts. To decrease that gap, Rauken & Kelman (2012) recommend increased collaboration between tourism authorities and SMEs to help decrease the impacts of weather and climate change.

In the developing country context, Bollinger & Mewes (2012) compiled case studies of Indian MSMEs in the metalworking and textile sectors. The authors found that MSMEs in these sectors experience direct impacts on their buildings, manufacturing processes and infrastructure (e.g., as a result of more frequent hot days or heavy rainfall), as well as indirect impacts on their supply chains and markets (e.g., due to rising energy and raw material prices). The authors concluded that climate change intensifies already existing challenges for MSMEs in India, including resource strain and infrastructural problems. The authors recommend that adaptation needs to consider not just the MSMEs, but also the local community, for instance, dams protecting MSMEs infrastructure from flooding are only successful if they do not increase the flooding risk for surrounding villages (see also GIZ, 2012).

Caretta (2014) conducted a case study of micro-loans to women in Kisumu, Kenya, which were provided to the women conditional on their accepting training in small business administration and agroforestry. Very favourable results were obtained in terms of both the well-being of the women's families and planned adaptation strategies. Coulibaly, Gbetibouo, Kundhlande, Sileshi, & Beedy (2015) undertook a case study of responses to crop failure in southern Malawi. They found that farmers do not respond

to climate variability per se but rather to crop failure. As a consequence, Coulibaly et al. (2015) recommend that policies for the more efficient communication of climate change threats should emphasize the risk of crop failure. Dougherty-Choux et al. (2015) pick up on many of the themes of the case studies examined above, particularly financing opportunities for MSMEs. They highlight a case study of guinea fowl production in Namibia where the costs of drip irrigation and granaries were outside the reach of most MSMEs unless access to finance was available. They also outline a number of other examples, including coping with drought and climate change in Zimbabwe; climate resilient water management and agricultural practice in Cambodia; agricultural biodiversity under climate change in Tajikistan; and adaptation to floods and drought in the Estero Real river watershed, Nicaragua.

4. Discussion and future research directions

As can be seen from the literature review above, there is a small body of existing evidence regarding MSME involvement in climate change adaptation, but also a lack of coherent insights into the drivers, barriers and outcomes of adaptation efforts, as well as into the suitability of different adaptation options. While there is a clear case for supporting MSME adaptation to climate change, many questions need further attention. First, at what level should adaptation decisions be undertaken (at the local or firm level, the regional level or the governmental level)? Global environmental change, and climate change in particular, extend beyond localities, such that regional planning seems warranted to improve social resilience. Secondly, to which types of change should MSMEs adapt and how should they prioritize? MSMEs face a myriad of challenges (e.g., climate change, biodiversity loss and water shortages, as well as issues associated with over-fertilization, which all affect the agricultural sector; see Rockström et al. 2009), and although not all of them affect every sector, many of them are interrelated. Here, further research is urgently needed to assist with the prioritization of adaptation needs.

Thirdly, who will bear the costs associated with adaptation? There is evidence that adaptation efforts on the regional and state levels have social benefits, but at the same time investments are needed into local infrastructure and adaptation plans. Further research is urgently needed to provide more detailed insights into the costs and benefits of adaptation at different levels of analysis (Busch, 2011; Galbreath, 2011; Kumar & Taylor, 2015; Linnenluecke, Griffiths, Winn, 2013; Mekonnen, 2014; Pinkse & Kolk, 2012; Stechemesser, Endrikat, Grasshoff, & Guenther, 2015; Whiteman, et al., 2011). Further research is also required that factors in an increasingly volatile future environment. Environmental volatility, such as an increase in the number and/or frequency of extreme weather events, will require the development of risk transfer solutions such as geographical diversification (Tang & Jang, 2011), insurance measures (Lashley & Warner, 2015; Phelan, 2011; Surminski & Oramas-Dorta, 2014), weather derivatives (Bank & Wiesner, 2011; Bertrand, Brusset, & Fortin, 2015; Isakson, 2015) and catastrophe bonds (Johnson, 2014; Johnson, 2015) that are affordable and accessible for MSMEs.

International governance and mechanisms for adaptation funding (see e.g., Linnenluecke & Griffiths, 2015) will also require further attention in research and policy debates. Significant commitments to fund adaptation efforts, especially those in least developed countries, have been made during recent UN Climate Change Conferences (e.g., the Special Climate Change Fund, the Least Developed Countries Fund and the Green Climate Fund), but the issues of how these investments will be allocated (and thus could potentially benefit the MSME sector) and of the resulting costs and benefits have not been fully resolved. Research on the optimal allocation and governance of funds and the integration of adaptation with other development objectives (Denton, et al., 2014; Dzebo & Stripple, 2015; Locatelli, Fedele, Fayolle, & Baglee, 2016) are therefore also important future research directions.

In addition, further research is needed regarding the availability, feasibility and affordability of different types of adaptation options for MSMEs, as well as their respective costs and benefits. A large number of adaptation options are imaginable, ranging from physical adaptation (e.g., updates to infrastructure, coastal protection) to technological solutions (e.g., water conservation measures) to social safety nets such as insurance, microcredit or other types of financial measures (see Noble et al., 2014). However, there is little evidence available regarding which of these measures are suitable to support MSME adaptation to climate change, especially given that the literature has identified significant barriers to adaptation and preparedness, including a lack of knowledge about information on, for example, costs and benefits and the different options available for SMEs (Wedawatta & Ingirige, 2012). Further research should focus on comparing the availability, feasibility and affordability of

different types of adaptation options for MSMEs in different industries and country settings.

As should be evident from the literature review, there is also a lack of focus on the increased likelihood of disasters. Many MSMEs will face increasing exposure to disasters as a result of climate change and global environmental change. This creates significant challenges in terms of facilitating economic recovery and creating functioning emergency response channels and funding streams. Disaster impacts, especially in developing countries, are particularly noticeable through (1) shortcomings in formal approaches to disaster responses (e.g., government agencies and emergency services are insufficiently prepared to respond to the disaster; arrangements for the provision of international assistance prove inadequate; capacities to provide food and shelter are limited) and (2) diminished local resources (e.g., damage to infrastructure and resulting breakdowns in power, transportation and communication) (Lindell & Prater, 2003). However, the literature shows that these issues pose not just significant threats but also opportunities for MSMEs to fill critical voids (Linnenluecke & McKnight, 2017). Entrepreneurial MSMEs can contribute to maintaining revenue streams and profitability by satisfying post-disaster demand for goods and services, which significantly aids community recovery. Innovative MSMEs can also offer specialized services from insurance to property restoration and contracting. In addition, there is increasing demand for firms offering online resources such as Google Earth, which enables volunteers and disaster aid organizations to access geographical information on damage (Goodchild & Glennon, 2010; Nourbakhsh et al., 2006; Zook, Graham, Shelton, & Gorman, 2010). Further research is also needed regarding MSME adaptation to and involvement in natural disasters, especially as these increase in frequency and/or intensity due to climate change.[5]

Lastly, it is now evident that breakthroughs in both adaptation and mitigation technologies are imminent (Linnenluecke, Smith, & McKnight, 2016). This will lead to the urgent requirement in adaptation research to consider how MSMEs can adapt not only to the physical impacts of global environmental change, but also to technology transitions. MSMEs that are able to manage such transitions successfully are likely to benefit from many opportunities. The coming technological breakthrough has given rise to studies of innovation challenges (De Stefano, Montes-Sancho, & Busch, 2016), funding streams and venture capital activity (Bürer & Wüstenhagen, 2009; Cumming, Henriques, & Sadorsky, 2016), as well as policy regimes that support clean-tech opportunities and uptake, including in developing countries (Gosens, Lu, & Coenen, 2015).

[5] Some assessments have been conducted on this topic: for example, the 2013 Global Assessment Report on Disaster Risk Reduction investigates how businesses can minimize disaster losses and impacts. See https://www.unisdr.org/we/inform/publications/33013.

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Conceptualizing micro, small and medium enterprise engagement in climate change adaptation

Abstract

Micro, Small and Medium size Enterprises (MSMEs) make up the economic and social fabric of most developing countries. They are, however, vulnerable to climate risks, especially those that primarily depend on natural resources that are exposed to climate hazards. Using examples from the agricultural sector, the article presents a conceptual framework to help understand the key barriers to adaptation that are faced by MSMEs and offers solutions to addressing the barriers. Many MSMEs find it challenging to address risks because of six key barriers: 1) insufficient knowledge about climate risks; 2) low level of ability to evaluate cost-effective adaptation measures; 3) limited financial resources; 4) low technical capacity to implement options; 5) unsupportive policies and regulations; and 6) insufficient social acceptance of an adaptation option. MSMEs need added support from policy-makers, large companies, donors and climate adaptation funds to adapt to climate change. This will mean supporting MSMEs to gain greater awareness of risks involved and providing them with a range of new opportunities to adapt to climate change.

1. Introduction

Micro, Small and Medium size Enterprises (MSMEs), i.e. those that employ between one and two hundred fifty people, make up the economic and social fabric of most developing countries (IFC, 2012). They include individuals who are farmers, fishers, shopkeepers and other providers of goods and services. Most MSMEs are part of the informal economy (Bacchetta, Ekkehard, & Bustamante, 2009). In Sub-Saharan Africa, South Asia, the Pacific Islands and Southeast Asia, 50% or more of total employment is generated by MSMEs, making them a key engine of job creation in many developing countries (UN, 2015). MSMEs are, however, vulnerable to climate change, since many depend primarily on natural resources that are highly vulnerable to climate risks. MSMEs generally have limited capacity to manage climate risks and opportunities, due in part to their short-term planning and investment horizons (WRI & UNDP, 2015). However, by implementing effective adaptation measures, they can spur socio-economic development and enhance the resilience of the communities they serve (IFC, 2012).

This article presents a conceptual framework to help understand how MSMEs can be supported to adapt to climate change and become more resilient. The article introduces a revised and updated summary of the framework published by the World Resources Institute and the United Nations Development Program (2015) in *Adapting from the Ground Up: Enabling Small Business in Development Countries to Adapt to Climate Change*. Section 2 highlights the key risks that businesses face and the drivers that motivate MSMEs to take on the climate change challenge, including minimizing risks to their businesses and harnessing new opportunities. Section 3 focuses on the barriers MSMEs may encounter when attempting to adapt, such as insufficient knowledge about climates, a low level of ability in evaluating cost-effective adaptation measures, limited financial and technical capacity to implement adaptation actions, prohibitive policies and regulations, and social barriers. Using examples, this section also provides solutions to how these barriers can be addressed. The examples come from agriculture, which is essential to jobs and incomes in many developing countries and is one the most vulnerable sectors, as climate change impacts increasingly affect food production and farmers' livelihoods. Section 4 concludes by suggesting how governments, large private companies and international climate funds can support MSMEs to become climate resilient.

2. Risks and drivers of adaptation

Adaptation is defined as the process of adjustment to actual or expected climate change and its effects, which helps to moderate or avoid harm, or exploit beneficial opportunities (IPCC, 2014). Many businesses want to adapt to climate change before it affects the quality and availability of the goods and services they provide, which in turn affects their bottom line and long-term viability (WRI & UNDP, 2015). Businesses face both direct climate risks and indirect non-climate risks that can disrupt their production of goods and services. Table 1 lists the various types of direct and indirect risks to agribusinesses as an example of how businesses can be impacted.

Table 1. Direct and Indirect Risk to Agribusinesses

Direct Climate Risks	→	Disruptions	←	Indirect Non-Climate Risks
• Physical assets		• Quantity and quality of production		• Access to finance
• Production processes		• Profit and income		• Economic and political instability
• Depletion of natural resources		• Business operations		• Risks to parts of supply chain
• Workers exposed to heat waves, floods, and storms		• Illness or loss of lives		
• Infrastructure				

Source: Adapted from WRI and UNDP, 2015.

Direct climate risks have immediate impacts on production. For instance, floods can damage physical assets such as storage facilities or affect production processes when machines used to produce goods no longer work. The inability to use assets and continue production processes leads to disruptions in business operations. Droughts and drying conditions can deplete natural resources, while intense rainfall can lead to soil erosion. Such weather-related events can disrupt the quantity and quality of food produced. Other weather-related events, such as floods, storms and heatwaves, directly affect the ability of farm workers to produce food if they become injured or ill or cannot get to work as a result. They may also damage the infrastructure, such as roads, needed to transport goods to markets. Damage to physical assets, food production processes, natural resources and infrastructure and the loss of lives can lead to the profits and incomes of MSMEs being disrupted.

MSMEs also face indirect risks, which may not be directly related to climate events but can influence how business is conducted. Indirect risks are beyond the control of MSMEs because they are part of the greater economic, political and social situation. For instance, in times of economic or political instability, the government may not be able to provide support, such as farming subsidies, or an environment that is safe to sell the goods and services that MSMEs provide, thus disrupting the ability of MSMEs to earn an income. Economic or political instability may also lead to financial institutions not being able to offer loans to MSMEs to run their businesses due to an uncertain environment, also potentially disrupting MSMEs' business operations. Parts of the supply chain may also be lost if, for instance, a multinational corporation that uses MSMEs in its supply chain moves to a new place due to cheaper labor costs. This may also create disruptions to business and a loss of income for MSMEs that produce for a product's supply chain.

Several reasons exist as to why MSMEs may be motivated to adapt to direct climate risks, as these risks have immediate impacts on production. For some MSMEs, a greater awareness of direct climate risks may motivate them to adapt to climate change. Others may be motivated to adapt if it becomes apparent to them that the benefits of adapting outweigh the financial costs. Another driver is the new opportunities that climate change can bring, such as increased demand for risk management technologies, products and services, or the opening of new markets. In the agricultural sector, examples include developing climate-resilient seeds, pest and disease control products, water-saving irrigation devices and weather risk insurance packages (Pauw, 2015). Those MSMEs that have operational flexibility, swift decision-making processes in place and an entrepreneurial spirit will be able to seize new opportunities more readily. Many of these opportunities are described further in Section 3.

3. Barriers and solutions to adapting to climate change

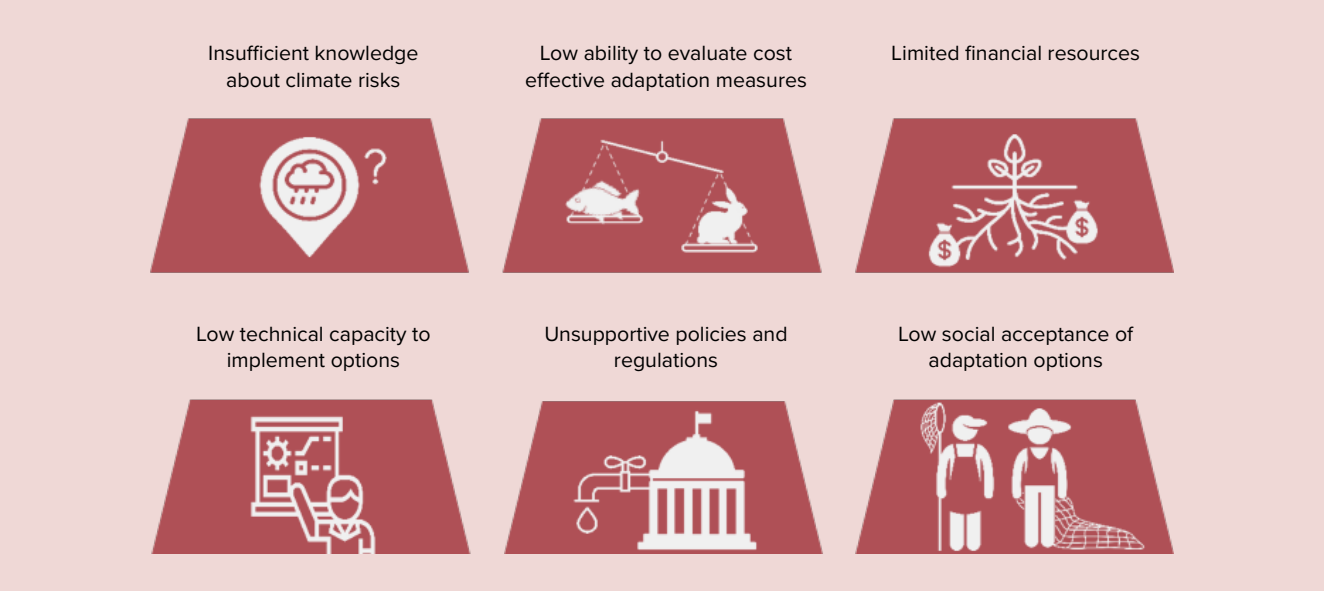
Even when MSMEs are motivated to adapt to climate change, they face several barriers to investing in adaptation measures. Six key barriers that prevent MSMEs from addressing climate change are discussed here. This section does not provide an exhaustive list of barriers and solutions but presents those that are most commonly identified. Figure 1 depicts the barriers to investing in adaptation measures. Examples of how solutions can address such barriers are also provided through cases from the agricultural sector in the following sections A to F.

(a) Climate information and risk assessment

Information about climate-related risks and uncertainties that is relevant to planning and decision-making processes among MSMEs is sometimes unavailable or inaccessible, which can lead such businesses to make investments based on 'gut feelings' (Danielson & Scott, 2006). If such information is available, however, MSMEs need to have the technical ability to conduct risk assessments by using climate information to understand the risks associated with climate change impacts. They also need information to weigh alternative risk reduction options and to determine the most cost-effective options for that sector and geography. Many MSMEs do not have the right information, tools and capacity to undertake risk assessments and choose the appropriate adaptation measures.

Since MSMEs typically have few resources to undertake risk assessment, the public sector, with the necessary assistance from donors, NGOs and international organizations, can disseminate information on climate risks and impacts. For example, in Chiredzi, Zimbabwe, MSMEs involved in agriculture struggled to plan for and assess their risks from rain-related weather events because they did not have access to adequate weather information. Farmers in remote areas may not have access to radio communications

Figure 1. Barriers to adaptation for MSMEs



or newspapers providing weather information. To provide information about possible weather events, the Zimbabwean Environmental Management Agency, with assistance from the United Nations Development Program (UNDP) and the Special Climate Change Fund, has installed eight weather stations and developed a customized rainfall-forecasting system to assist farmers in Chiredzi. Farmers can now minimize their direct risks and plan for climate variability and extreme events. This has led to visible improvements in crop cycle planning, drought preparedness and adjusted farming practices to protect harvests (UNDP, 2014).

(b) Evaluation of cost-effective adaptation measures

Once a risk assessment has been conducted and various adaptation options have been identified, a cost-benefit analysis should be carried out to assess the price, operating costs and sustainability of production. This could also mean comparing the cost of an adaptation option, such as planting drought-tolerant crops, compared to the cost of planting traditional crops that are not climate-resilient to assess which option will be more cost-effective over time. Knowledge is limited, and few tools are available for cost-benefit analyses of location- and time-specific adaptation measures. Even when a cost-benefit analysis is conducted, businesses may still not invest in adaptation measures unless there are clear benefits in terms of risks reduced by and/or the profitability of adopting a new climate-resilient business opportunity. This is especially the case when there are high upfront costs.

With help from the Department of Livestock and UNDP, fishermen in Benin have been able to adapt to frequent and severe floods that have impacted vulnerable communities (WRI & UNDP, 2015). UNDP and the Department of Livestock assisted MSMEs in identifying various livelihood strategies based on a cost-benefit analysis. Once various options had been weighed, the fishermen chose a new business opportunity that was more cost-effective for them, namely placing rabbit-breeding facilities on elevated platforms, where they will have protection from the increased frequency of flooding. In addition to acquiring an alternative income during periods when fishing cannot be undertaken, the diversification of economic activity and a cost-effective adaptation strategy have created a new local market for rabbit meat that has begun to transform local village economies.

(c) Financial capacity to implement adaptation measures

Even after conducting risk assessments and identifying cost-effective adaptation options, limited financial capacity can impede the implementation of adaptation options.

According to the International Finance Corporation, MSMEs worldwide face a US $2.1 to US $2.6 trillion gap in financing. This amounts to approximately 200 to 245 million formal and informal businesses that need loans, insurance and credit, but are unable to access these financial and risk-management instruments (Stein, Ardic, & Hommes, 2010). One reason why MSMEs cannot access funds is because banks and other financial intermediaries are reluctant to invest in adaptation because the risks of lending appear too high, especially if financial institutions do not have full information regarding climate risks. Another reason is the rising costs of adaptation, which are expected to increase in developing countries. UNEP (2015) estimates that the costs will amount to $300 billion in 2030, rising to $500 billion by 2050. Rising costs will make it difficult to finance adaptation measures that have large upfront costs, relatively long payback times and uncertainties with respect to future climate impacts. The high costs of adaptation and the lack of support from financial institutions lead MSMEs to rely on social networks for small loans and start-up cash or to benefit from microfinance loans (Dalberg, 2011; Stein et al., 2013).

Some MSMEs, however, can access loans, grants and seed capital through projects supported by multilateral organizations and governments. For instance, many poor farmers in Namibia were not able to afford drip irrigation technologies. Although this technology helps conserve water in a drying climate, the start-up costs for an investment in drip irrigation is estimated at US $11,000 for one to two hectares of land (EIF Namibia, 2016; MAWF, 2012; UNDP, 2015; WRI & UNDP, 2015). One way to help such farmers is to develop a subsidization mechanism in the form of a soft loan giving farmers access to credit at reduced rates (MAWF, 2012). Soft loans from the government helped install drip irrigation, leading farmers to reduce the direct risks from climate change and increase their agricultural yields by 25% over the life of the UNDP-supported project. Annual incomes rose from USD $25,140 every planting season for the cultivation of one hectare of farmland to USD $31,425 per hectare (UNDP, 2015). Namibia's Environmental Investment Fund is also helping farmers by providing grants and loans to invest in climate-smart agriculture (EIF Namibia, 2016). It should be noted, however, that some financial instruments may be liable to maladaptation. For instance, financially supporting too many irrigation projects could lead to water resources being depleted. Therefore, such instruments need to be carefully implemented while looking at the costs and consequences of implementing them.

Considering the constraints on government funding, there may be times when MSMEs can finance their own adaptation projects or large companies can finance smaller companies to adapt by setting up partnerships. For instance, for many MSMEs, energy consumption accounts for up to 50% of total business costs. MSMEs may have the capital to install energy-saving technologies, such as photovoltaic cells. Saving money on energy bills through such technology lowers operating costs. MSMEs could then reinvest the amount saved through low energy bills and finance other adaptation options. Larger private companies can also provide finance to MSMEs (Pauw, 2015). For example, early warning systems are usually installed by the public sector. However, motivated by a new business opportunity and market, Skymet, India's first weather-forecasting company, funds and supplies accurate weather information to farmers through text messages in partnership with Nokia. Skymet provides text-based weather forecasts through Nokia Life-Tools to 110,000 farmers, helping them make better decisions on irrigation and storage (Intellecap, 2010). In this case, partnerships were forged between two large private companies, Nokia and Skymet, who worked together jointly to fund the provision of weather-based information vital for adaptation among farmers to reduce their direct climate risks.

(d) Technical capacity to implement adaptation measures

MSMEs face major challenges regarding the technical capacity to implement adaptation options. For instance, farmers may not know how to manage new drought- and flood-tolerant crops or to develop business plans that support adaptation. They require technical support through training in how to manage new agricultural technologies, such as climate-resilient crops, and to develop business plans with adaptation in mind.

The public sector plays a large role in many countries in providing technical support to implement new adaptation technologies and develop business plans. In Ethiopia, for instance, the government supported several approaches to demonstrate to MSMEs the benefits of new climate-resilient crops as a business opportunity (WRI and UNDP, 2015). Financing from the Least Developed Countries Fund and technical assistance from the government through the

Promoting Autonomous Adaptation project enabled 17 MSMEs to receive technical training from government extension officers to help diversify their incomes by growing drought-resistant crops. The government also introduced solar water pumps and drought-resistant seeds, and developed farmers' skills to use such new technologies. Although it is unknown whether the training included traditional knowledge, such training usually uses farmers' traditional knowledge about their environment (FAO, 2013; Nyong, Adesina, & Elasha, 2007; Swiderska, Song, Li, Reid, & Mutta, 2011). In this project, each farmer invested $1,380 in solar pumps and drought-resistant seeds and generated $3,480 in one season.

Although the government plays a significant role in providing technical support, it should be noted that large private companies may also provide technical support directly to smallholder MSMEs. In Zambia, for instance, a large private seed company provides climate resilient seeds to MSMEs, as well as extension services and the marketing of products (Pauw, 2015). Multinational companies such as Café Direct and Unilever Tea are training thousands of coffee and tea-growers in Africa and Latin America to adapt by responding to changing weather patterns by investing in irrigation (UNFCCC, 2014).

In some situations, MSMEs may have promising business ideas for climate-resilient products and services but find it difficult to develop credible business plans for the full-scale commercialization of their products (PwC, 2013). The development of new products and services requires specific technical skills and knowledge of how to develop an idea and commercialize it. Networks now exist such as the Private Financing Advisory Network (PFAN, 2017), which identifies promising climate change projects at an early stage and provides mentoring in developing a business plan, making an investment pitch and growth strategy, significantly enhancing the prospect of financial support for the project. Although PFAN mostly supports mitigation projects, it is starting to support business plan development for adaptation projects related to agriculture in Kenya. Similarly, the Climate Business Innovation Network (CBIN, 2017) helps clean technology start-ups to pioneer new business models and technologies or adapt existing models to a new market. The Network provides technical training to intermediary organizations such as incubators, accelerators, innovation hubs, cluster associations, MSME support centers and green development agencies to help MSMEs scale up their start-ups. Such networks can help MSMEs produce goods and services that boost resilience.

(e) Policies and regulations

Government institutions can play an important role in encouraging adaptation practices, incentivizing investments, providing technical training, funding adaptation measures and communicating information and knowledge to local businesses. Although many national governments have committed themselves to climate change adaptation policies and plans, such as Nationally Determined Contributions, National Adaptation Plans and integrated adaptation into Five-Year development plans, private-sector engagement in policy-making is limited. The failure to coordinate with MSMEs and include their perspectives through consultation processes may lead to counter-productive policies being devised that discourage adaptation and create obstacles to business investment (IFC & EBRD, 2013).

An example from India shows that public policies that provide energy and water subsidies to regulate prices and avoid possible market failures can sometimes be counter-productive and lead to maladaptation. Subsidy policies sometimes do not take into consideration the possibility of their creating a lack of incentives for MSMEs to conserve water and adapt to climate change (Clements et al., 2013; UNEP, 2016). In India, a combination of water policies, energy subsidies and the non-payment of subsidies by the government made it difficult to introduce and scale up water-saving adaptation options, such as drip irrigation. Jain Irrigation Systems (JIS), a medium-size enterprise, found a new business opportunity in drip irrigation technology, but found it difficult to make a profit from sales in drought-stricken areas. The challenge it faced was that farmers were paying very low prices for water due to subsidies and were pumping unsustainable amounts of groundwater through small-scale water pumps that run on subsidized energy. Although this caused groundwater depletion, farmers had little incentive to invest in expensive drip irrigation technology to save water.

Because of its financial capacity, in 2012 JIS invested in its own non-banking finance company (NBFC) to provide credit to farmers. The NBFC lends to farmers so that JIS gets the full price of the drip irrigation technology when it is sold to farmers. The farmer then assigns the subsidy to the NBFC. The NBFC takes some pressure off JIS's balance sheet, making it possible for JIS to pass the benefits of lower

working capital loans to farmers to buy drip irrigation technology. This example shows that some MSMEs that have the financial capital, such as JIS, can create their own enabling environment and invest in adaptation despite counter-productive policies. It also shows that governments should conduct integrated planning across various ministries (e.g. water and energy) to implement adaptation policies that complements use of energy and water in a sustainable manner.

(f) Social dimensions of climate change

Although the socioeconomic context is often overlooked, it can be a significant barrier to the adoption of adaptation measures, as can ethics, risk perception, and culture (Tompkins & Adger, 2004). For instance, men generally have lower perceptions of risk than women, possibly leading men to make lower investments in adaptation (Jones & Boyd, 2011). Other social dynamics can also play a role. In Nepal and India, the caste system makes it more difficult for the lower castes, who are poor and marginalized, to adapt to climate change (Jones, 2010). In Nepal, the lower castes are prevented from accessing social safety nets, such as aid distribution, when a natural disaster strikes, and are not allowed to enter 'safe spots' during times of flood. In India, the lower castes are prevented from accessing water at times of water stress. Such cultural practices enable only the wealthy members of the higher castes to adapt to climate change. Overcoming social and cultural barriers requires a good understanding of the dynamics of MSMEs communities and of long-term investments in private-sector engagement.

An example from Cambodia shows how cultural attitudes and habits are surmountable through a collaborative approach that offers farmers first-hand experience of the advantages of implementing flood-tolerant crops as an adaptation measure. Initially it was difficult for the Ministry of Agriculture in Cambodia to convince farmers to adopt climate-resilient agricultural practices such as planting flood-tolerant rice. This was because poorer, male farmers thought that planting such rice varieties would be risky because it would cost more to plant. Women too did not initially support planting flood-tolerant rice because they thought that they did not have the knowledge and experience to do so. With support from UNDP project staff, farmers eventually embraced flood-tolerant rice as an adaptation option when it was presented to them as a 'life improvement' and a new business opportunity. Using video materials, the project team facilitated discussions of perceptions of risk and encouraged farmers to articulate their experiences with changing weather patterns and think how they could adapt to floods. Demonstration sites were also used for technical learning from the beginning of the project, along with recording the expenses and incomes of trial users and calculating the monetary benefits. These demonstrations of the tangible costs and benefits led farmers to agree to adopt this new farming technology. This process lowered the social barriers to adopting adaptation technologies by shifting farmers' perceptions of risk towards this new business opportunity (WRI & UNDP, 2015).

4. Concluding remarks

The framework presented in this article provides a way to understand the various direct and indirect risks MSMEs face as they try to adapt to climate change. Many MSMEs find it challenging to address risks due to six key barriers: 1) insufficient climate knowledge and risk assessment; 2) insufficient ability to evaluate cost-effective adaptation options; 3) limited financial availability to implement options; 4) low levels of the technical capacity to implement options; 5) unsupportive policies and regulations; and 6) low social acceptance of an adaptation option. The framework discusses these barriers and offers solutions though examples that can counteract the barriers.

To implement many of the solutions described here, MSMEs still need added support from policy-makers, large companies, donors and climate adaptation funds to adapt to climate change. *Adapting from the Ground Up* (WRI & UNDP, 2015) ends by recommending ways in which policy-makers, large companies and climate funds can support MSMEs in addressing some of the risks and barriers discussed in this article so that they are able to adapt to climate change. The following paragraphs summarize those recommendations.

Government policy-makers should develop policies that stimulate MSMEs to invest in adaptation. This can be achieved through instruments such as national and sector-specific adaptation plans and long-term economic development planning strategies and frameworks (see section B.4). Developing country governments should also actively engage with other actors who can assist them in implementing adaptation measures. For instance, the Zimbabwean Environmental Management Agency engaged with UNDP to help farmers become aware of climate risks by

providing forecasts. In Benin, the Department of Livestock worked with UNDP to conduct cost-benefit analyses of various adaptation options to provide fishermen with affordable options. Bottom-up or local-level approaches to identifying key policy, cultural, financial and technical barriers to investing in risk management strategies by MSMEs should also be promoted by governments. For example, in Cambodia, as we have just seen, the Ministry of Agriculture worked with UNDP to create a cultural shift among farmers who were initially hesitant to plant flood-tolerant rice. Instead they were encouraged to view this crop as a way to improve their livelihoods and take part in a new business opportunity.

Large private-sector actors and multinationals often rely on MSMEs as part of the supply chains for their products. To sustain their own businesses, multinational or other large companies may invest in making MSMEs within their supply chains more resilient, so that neither MSMEs nor large companies face disruptions in their production due to the impacts of climate change. Large companies and investors can support MSMEs within their supply chains by providing finance and technical assistance. For instance, Café Direct and Unilever Tea are training thousands of coffee and tea-growers in Africa and Latin America who are part of their respective supply chains to adapt by training and investing in irrigation methods so that both multinational corporations and MSMEs can protect their businesses from droughts. There may be disincentives where large companies offer finance and technical assistance to MSMEs that are working with competitors. This may, however, be a risk that large companies are willing to take to protect their own supply chains. In addition to providing public grants or loans, governments should find ways to work with multinational corporations, financial institutions and investors to ensure that a variety of financial instruments are available to support such initiatives.

Climate funds can support and complement national efforts by creating regional or national networks to help MSMEs develop product ideas into bankable projects, to support capacity development for implementation and to link businesses to possible investors. Climate funds, such as the Green Climate Fund (GCF), play a catalytic role by ensuring that they support two kinds of projects and programs: those that create the enabling conditions for MSMEs to make investments in building up their own resilience to climate impacts, and those that promote products and services that support, facilitate or advance adaptation at scale. GCF's Private Sector Facility helps fund and mobilize institutional investors and GCF funds to invest in climate change projects and support MSMEs. The GCF has also established a pilot program to support MSMEs and allocate up to $200 million to fund climate change projects involving MSMEs (Green Climate Fund, 2016) (see section B.2).

Addressing the barriers and supporting the enabling factor MSMEs face when adapting to climate change will require leadership within MSMEs, as well as from governments, large companies, and climate funds. It will also require investing time and finances. Although actions to enable MSMEs to adapt to climate change could be a large undertaking, it will lead to supporting some of the most vulnerable and poor people to adapt to climate change and creating resilient societies.

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An opportunistic approach to climate resilience in developing countries

Global climate change is usually framed in terms of risk rather than opportunity. This is understandable as climate-related risks pose a serious threat to public and private assets, organizational continuity, settlements, livelihoods and the security of water, food, and energy resources. When "climate-related opportunities" are discussed, these are usually related to climate mitigation, such as clean energy investments in solar or wind, energy efficiency, carbon offset and trading programs and other actions that serve to reduce greenhouse emissions. However, private opportunities related to climate resilience are far less recognized. Climate resilience is the process by which stakeholders protect people, property and operational continuity from climate risks such as drought, floods, heatwaves, sea level rise, wildfires, invasive pests, etc.

This paper argues that the demand for products and services needed to help people reduce their exposure to climate risks is a significant opportunity for businesses, including some of the smallest, in developing countries and around the world. Moreover, the market for these products and services, or climate resilience solutions, is large and remains unmeasured. Private action in climate resilience generates local capacities and livelihoods and has the potential to contribute to broader efforts on climate adaptation.

* The views and opinions expressed in this article are those of the author alone, and do not necessarily reflect the views or official positions of the Inter-American Development Bank, the Nordic Development Fund or any other organization.

1. Climate risk: a common threat and an uncommon opportunity

Global climate change is one of the greatest social, economic and environmental challenges facing humanity. Until recently, climate change mitigation, or the efforts to reduce global greenhouse gas emissions Global climate change is usually framed in terms of risk rather than opportunity. This is understandable as climate-related risks pose a serious threat to public and private assets, organizational continuity, settlements, livelihoods and the security of water, food, and energy resources. When "climate-related opportunities" are discussed, these are usually related to climate mitigation, such as clean energy investments in solar or wind, energy efficiency, carbon offset and trading programs and other actions that serve to reduce greenhouse emissions. However, private opportunities related to climate resilience are far less recognized. Climate resilience is the process by which stakeholders protect people, property and operational continuity from climate risks such as drought, floods, heatwaves, sea level rise, wildfires, invasive pests, etc. This paper argues that the demand for products and services needed to help people reduce their exposure to climate risks is a significant opportunity for businesses, including some of the smallest, in developing countries and around the world. Moreover, the market for these products and services, or climate resilience solutions, is large and remains unmeasured. Private action in climate resilience generates local capacities and livelihoods and has the potential to contribute to broader efforts in climate adaptation, have received the greatest focus in the response to this challenge. Currently, growing attention is being paid to climate adaptation and resilience, and to policies and strategies for helping humanity to adapt to and navigate the climate change that is already happening. This paper will argue first, that the drive to build climate resilience is a significant opportunity for many businesses, including some of the smallest, in developing countries and around the world; and secondly, that the private response to resilience building can create local capacities in resilience, generate livelihoods and also contribute to larger efforts toward adaptation.

This paper draws in part upon the early lessons to emerge from the Proadapt program, a technical assistance initiative of the Multilateral Investment Fund of the Inter-American Development Bank and the Nordic Development Fund (see proadapt.org). Proadapt has two basic objectives. The first is to foster private-sector development by promoting climate resilience and related business opportunities for micro-, small and medium-size enterprises (MSMEs) and their local communities in Latin America and the Caribbean (LAC). A second major objective is to broker and share new knowledge, best practices and innovative tools that foster private-sector resilience in developing regions and other markets.

The design of this programme was based on several assumptions. The first is that global climate change is a growing economic, social and environmental threat-multiplier that challenges water, food and energy security, settlements, health, livelihoods and operational continuity. Drought, flooding, storm surges, sea-level rises, heatwaves, cyclonic winds, wildfires and invasive pests are major climate risks. Extreme weather events such as hurricanes and severe floods receive the most public attention, but longer-term incremental climatic changes, such as changing precipitation and temperature patterns, may prove more serious and costly, particularly with respect to food and water security and viability of settlements and productive assets.

Secondly, barring the introduction of radical new technologies or a dramatic shift to negative net greenhouse gas (GHG) emissions, the globe is likely to be locked into greater warming, climate variability and extreme weather events for the foreseeable future (Solomon, et al., 2010). Climate change is happening now, and developing countries are particularly vulnerable to this threat given widespread poverty, adverse geography, low resource endowments, weak adaptive capacity and, in many cases, large rural populations dependent upon smallholder agriculture (Ensor et al., 2015). Climate resilience, or the process by which stakeholders seek to protect people, property and operational continuity from climate risks, is now an urgent task for developing nations (Ensor et al., 2015).

The third assumption is that climate risks are driving a growing demand for private climate resilience solutions. Public and private stakeholders everywhere, including public entities, enterprises, households and property owners, are currently purchasing a range products and services, or 'climate resilience solutions,' to help them manage their exposure to climate risks. These solutions, such as water-efficient technologies, water-harvesting services, low-drip and efficient irrigation, wind-, flood- and heat-resilient building materials, flood control, new financial and

insurance products, early warning systems, applied climate analytics, back-up power generation, drought-resistant seeds and new health-care products, among many other solutions, are being sold in local markets around the world. These products and services are produced or distributed locally in both developed and developing economies, typically involving little or no public support. In many cases the public sector is also a final customer for these products and services.

Proadapt has sponsored several international conferences, round-table discussions and consultations with private and public stakeholders on the issue of sector adaptation and resilience. Several consistent observations arise from these interactions. First, climate adaptation and resilience have been understudied and underfunded as compared with mitigation. Secondly, while the public sector is critical to national resilience-building, the private sector is also producing resilience solutions and innovating in the fields of climate-resilient products, services, technologies and processes. Thirdly, low awareness, uncertainties over the location, timing and magnitude of climate risks, a lack of common metrics for physical climate risks and difficulties in applying scientific climate data to business and investment decisions continue to hamper both public- and private-sector progress on climate resilience. But in spite of these challenges, a growing number of private actors now view climate risk as more than just a threat, but as a strategic business opportunity.

2. Private climate resilience seems hidden in plain sight

Most businesses, large and small, do not use climate terminology to describe their activities. 'Climate adaptation' and 'resilience' are not terms found in financial statements. Climate resilience in the private sector is still largely described in the language of business: risk management, finance, marketing, product development, logistics and so on. When enterprises refer to climatic conditions and related risks, 'weather' or 'natural disaster' are the typical terms used. Companies with 'sustainability' programmes often pursue responsible environmental stewardship by pursuing short-term environmental goals and meeting sustainability compliance standards. Many of these goals explicitly refer to climate change, but most focus only on mitigation-related activities. Such programs often pursue cost-effective reductions in environmental footprints and greenhouse gas emissions through cleaner and more efficient energy and water use and reducing waste of all types. These efforts can also significantly reduce production costs while enhancing a 'green' reputation (see Dauvergne and Lister, 2013). However, currently climate resilience is not taken into account in most business sustainability programmes (see Marsh & McLennon, 2017).

As demand for climate resilience increases, privately produced solutions remain largely unseen by policy-makers in many places. In the private sector itself, climate risk and resilience tend to be framed using different language than that used by public authorities. The first basic private framing of this challenge is as a set of *risks* that impact operational continuity, business assets and property, supply chains, logistics and other variables affecting competitiveness. As already indicated, these risks are usually described as 'weather' or 'natural disaster' risks.

By whatever name, these risks fuel the demand for a wide range of products and services that help businesses, households and public entities to manage their exposure to flooding, storm surges, drought, precipitation variability, heat waves, cyclonic wind, invasive pests and wildfires, among other risks, more effectively. This demand directly influences the second basic private framing of climate resilience, namely that it is a growing *business opportunity.* From this perspective, one person's climate risks may be another's opportunity in the form of sales of resilient products or services. Public authorities may capture this market activity using conventional economic statistics, but none of these actions is recognized as a private-sector contribution to climate resilience.

3. Proadapt: climate resilience and business opportunities in Latin America and the Caribbean

A major objective of the Proadapt programme is to raise awareness and increase the resilience of smaller enterprises in Latin America and the Caribbean. To date, the programme has approved eleven technical assistance projects in fourteen countries: Argentina, Bahamas, Belize, Bolivia, Brazil, El Salvador, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay and Saint Lucia, with others in the pipeline (see proadapt.org). Proadapt began with a primary focus on building climate resilience in MSMEs and on supporting applied market research to inform business resilience strategies. The program supports market assessments of various products and sectors in several countries, including

agriculture, fisheries, housing and construction, water and sanitation, and transportation. Most new private-sector partners in the Proadapt programme have identified climate variability (typically framed in terms of 'weather') as a serious or material operating risk to their business. Consequently, there is a strong interest at the beginning of projects in developing a better understanding of climate resilience and of mechanisms for protecting business property, supply chains and operational continuity.

The Proadapt programme is 'model free,' in the sense that it borrows from various approaches to climate adaptation and resilience in order to help enterprises manage climate risks and develop related market opportunities more effectively. Proadapt works with non-profit entities and firms of different sizes, including larger anchor firms that function as hubs for supply chains composed of smaller enterprises. Larger, better capitalized firms have the resources to disseminate best practices and facilitate market access for smaller suppliers. This is important in developing countries where strong private partners can be critical to producing successful outcomes in private-sector programmes.

Building climate resilient farmers in the Brazilian Sertão
This first Proadapt project, aims to increase climate resilience in the agricultural sector in Bacia do Jacuipe in the Sertão region of Bahia in north eastern Brazil. The Sertão is one of the largest, semi-arid regions on the planet and the poorest area in Brazil. The Sertão is very climate vulnerable, making life difficult for poor smallholder family farmers. The project provides assistance to six agricultural cooperatives (three of which are headed by women) who have banded together to focus on climate adaptation. From these cooperatives, 800 smallholders who produce dairy and meat products were chosen to participate in the initiative. Farmers, cooperatives, policy makers, and local and regional financial institutions have received training on an adaptive, climate-smart agricultural production system based on 17 field tested, low cost and practical technologies. These have been shown to improve productivity, reduce the use of water and other resources, and help extend production times in the face of drought and heat waves. To date, the project has achieved a 27% average daily increase in milk production and an 85% increase in net earnings per family for milk and lamb. The project has also fostered productive reforestation in 100% of pasture areas.

In its efforts to promote information sharing and learning networks, Proadapt works with businesses and investors, public partners, climate experts, international donors, investors and others who recognize climate resilience as a market opportunity. Consequently, the Proadapt network is diverse, including smallholder farmer cooperatives, private-sector associations, universities, technical institutes, entrepreneurs, specialized consultancies, equity investors and others. Proadapt was launched in 2013 and has put over US$23 million to work in the region thus far, including local counterpart resources and international climate finance (such as the Pilot Program for Climate Resilience, a climate investment fund (see https://www.climateinvestmentfunds.org).

Early demand for projects came from the agricultural sector. Before designing individual projects, market assessments of climate risks in various product and crop groups were conducted in sectors such as cocoa, dairy products, honey and other less studied crops. Projects began with awareness-raising and stakeholder outreach, with consultation among smallholders, anchor firms and other stakeholders. This was followed by training and the implementation of resilient practices, including more efficient methods of water usage; more resilient, local sources of animal feed (e.g. piloting the use of a plentiful drought-resistant cactus for animal feed); better measurement of temperature and moisture; the use of economical equipment for more adaptive tillage; better measures against heat in storage and transportation; and incorporating applied climate data into business planning, among many other practices. For a smallholder's family, building climate resilience is not an abstract concept. In a place like the Brazilian Sertão, as shown in the above box, or the Gran Chaco, resilience is about concrete progress in acquiring the capacities needed to survive a drought or some other climate shock long enough to stay in business, thereby saving an enterprise, a livelihood and a family's income.

For anchor firms, greater climate resilience can mean helping local suppliers to deliver the quantity and quality of products needed at the right time, even in the face of variable climate risks, as illustrated in the *Building Climate Resilience in the Fine Cocoa and Honey Sectors* project in Nicaragua.

During the initial design phase of the overall Proadapt programme, the focus of assistance was on building climate resilience in enterprises; promoting business opportunities was a secondary concern. However, early partners in agriculture, housing and the built environment, the financial

Building climate resilience in the fine cocoa and honey sectors (Nicaragua)
Nicaragua is capable of producing a very fine quality of cocoa, a product that is a more climate resilient alternative to coffee. Nicaragua is also one of the most climate vulnerable countries in world and the poorest country in Latin America. An agricultural anchor firm, Ingemman, has undertaken an ambitious effort to improve the climate resilience of its supply chain, composed of smallholder family cocoa and honey producers. The project provides technical advice, market intelligence and access to credit to improve the climate resilience of up to 1000 small producers of both honey and fine cocoa, over one quarter of whom are women. The project is active in the departments of Nueva Segovia, Matagalpa, and Jinotega. In the first year of the project, six demonstration sites for testing and validation of techniques, best agricultural practices, productivity measurement, and other activities have been established. 138 fine cocoa producers have been trained in climate resilience, 27 producers have been trained in climate and phenological (i.e. the study of flowering, breeding, and migration and other variables related to climatic conditions) observation and 21 producers have been trained in technical plantations and farm management. The project also improves access to data and projections for climate risks and has created an Interactive Agro-meteorological Information System (SIA) running on a web platform (www.sia.proyectoadapta.com). The SIA is an innovative tool that provides timely information for decision making related to climate risk in the cacao and honey value chains. The project also works with local and international experts on targeted climate modelling climate scenarios against potential impacts on cocoa and similar crops in Nicaragua.

sector and transportation, among others, expressed interest in developing opportunities related to resilience. For example, in the *Building Climate Resilient Farmers in the Brazilian Sertão* project, mentioned above, the six founding agricultural cooperatives are extending work on a menu of affordable technologies to include a commercial distribution platform and work on a credit programme to help small farmers purchase these technologies. In Nicaragua, Ingemann recognized the commercial potential of resilience-building across their supply chain as a means of improving cocoa quality and yields that also improved the family livelihoods of small producers. Early discussions with the Jamaican National Group (which includes the largest mortgage lender in the Caribbean) indicated a strong interest in promoting housing products that conserve water, a climate-resilient response in the Caribbean basin, where drought threatens water security.

Early Proadapt discussions with financial institutions, including micro-lenders, also revealed a growing concern over the impact of climate risks on financial portfolios. This reflects growing international concern over the lack of metrics and reporting protocols for climate-related risks in financial markets. The Task Force on the Financial Disclosure of Climate-Related Risks (TCFD) has convened a high-level group of financial institutions and firms from several sectors to address this issue (see TCFD, 2017). Proadapt is currently working with some of the largest lenders in Brazil to develop a methodology that would help lenders reduce exposure to climate risks in agricultural portfolios. This is another potential growth opportunity for enterprises that develop these solutions.

Proadapt is also participating in investor networks interested in climate resilience as an investment opportunity, such as the Global Adaptation and Resilience Investment Roundtable or GARI (Koh, Mazzacurati, & Swann, 2016). GARI has also just produced the first guide in climate-resilient solutions for investors (Koh, Mazzacurati, & Trabacchi, 2017). Proadapt has also actively promoted *CRAFT,* the world's first private investment vehicle dedicated to expanding technologies and solutions for climate adaptation and resilience in developing and developed countries (described below).

The Proadapt program is still under implementation, with just one project nearing completion. While a formal programme evaluation has yet to be carried out, an interim programme review has recently been conducted. This review, along with feedback from projects and a network of partners, inform the following observations and emerging lessons that underscore the growing potential of private-sector resilience.

(i) Private resilience solutions: a market unmeasured
The market for products and services that help buyers to manage climate risks already exists but remains largely hidden in plain sight. No public or private organization collects systematic data on private-sector resilience, and, as already mentioned, the private sector itself rarely uses climate terminology to describe its actions. Several international development programmes exist to help local communities and small and microenterprises in building greater climate resilience. Proadapt is the only programme that also focuses on resilience as part of a market response and that fosters access to market intelligence and scientific data and technical and business advice that can inform

Financing water adaptation in Jamaica's new housing sector

Variable precipitation patterns have exacerbated water shortages across the Caribbean basin. Proadapt is helping the Jamaica National Group (JNG), the Caribbean's largest mortgage lender, to implement a wide range of water saving technologies and measures in new housing. Proadapt partnered with the Pilot Program for Climate Resilience (see climateinvestmenfunds.org) to enable the JNG to offer targeted credit for mortgage borrowers interested in a suite of water efficient technologies and options for their new homes. As part of the project, the Jamaican National Foundation will offer training and market intelligence to local businesses that sell, install and repair these technologies, as well as provide support to other entrepreneurs working on climate resilient solutions. The broader goal is to replicate and scale this private model beyond Jamaica and across the Caribbean. While this project is just starting, JNG is optimistic about the prospect for additional lending in water efficiency and related technologies in housing and the built environment.

strategic opportunities for MSMEs. A new study sponsored by Proadapt will examine the growing market opportunities posed by climate resilience. The inquiry will assess the markets for climate-resilient solutions in two sectors, agriculture and transportation, in three emerging markets: Colombia, South Africa and the Philippines. These solutions take the form of products and services that help buyers manage their exposure to climate risks more effectively, as well as emerging investment models and public-private partnerships that help to reduce climate vulnerability.

Early evidence suggests that in some cases building resilience within enterprises (the 'demand side' of the resilience market) can lead to promising ideas for solutions that can be developed and marketed elsewhere (the supply side of the market). For example, Ingemann, the agricultural anchor firm in Nicaragua, recognized the need to give smallholder producers in its cocoa and honey supply chains greater access to credit, and it is therefore exploring the possibility of opening a microfinance arm with its partners to provide finance for suppliers to improve their resilience. In another case, Proadapt is supporting greater water efficiency in new housing in the project *Financing Water Adaptation in Jamaica's New Housing Sector*, a project that will also stimulate a supply-side response by small businesses that market, install, repair and service water-saving technologies (see above).

(ii) Climate resilience as an opportunity for enterprise improvement

Drought, flood, water insecurity, shifting precipitation patterns, heat waves and invasive pests are universal threats that have prompted leading stakeholders in agriculture to be proactive in dealing with climate risks. The term 'climate-smart agriculture' refers to a bundle of best practices that are widely associated with climate resilience in this sector. Proadapt's early experience in agriculture demonstrated that many 'resilient' interventions were also considered best practices for the systemic improvement of agricultural production. Better cropping systems, cultivation practices, control of weeds and pests, reduction of soil-borne diseases and other practices improve resilience, product quality and profitability. Based on this experience, Proadapt's assistance began to frame resilience-building as part of a broader business framework for the improved management of risks, costs, productivity and product quality, not just in agriculture but in other sectors as well. While still a conceptual work in progress, mainstreaming climate resilience into systemic improvement of processes in enterprises will likely become a best practice for navigating climate variability, as demonstrated in the Blue Harvest project in El Salvador, Honduras and Nicaragua, described below.

The incorporation of climate reliance should be part of business planning decisions in many sectors. However, planning and decisions that are practised as a linear activity, i.e. from problem identification to a search for solutions, followed by decisions and implementation, will likely be insufficient for responding to the complex challenge of climate risks. For instance, an organization may undergo a climate vulnerability assessment, implement suggested changes and then declare itself to be 'resilient.'[1] But climate risks, data, market intelligence and climate analytics are continually evolving. A systems approach that pursues decisions through a continual feedback process, viewing a problem not in isolation but as part of a larger system, is better suited to the dynamic challenge of climate change (see Maani, 2013).

[1] Various models are available for assessing an organization's current and potential physical and financial risks resulting from climate change. The term "climate vulnerability assessment" is a common, if somewhat generic term used to describe a systemic approach to analysing an entity's vulnerability to climate risks (see, for example, the European Climate Adaptation Platform, http://climate-adapt.eea.europa.eu/metadata/tools/climate-change-vulnerability-assessment-and-adaptation-tools).

Blue harvest: a new sustainable production model for small holder coffee farmers

In El Salvador, Honduras and Nicaragua, climate resilience is an important part of integrated drive to improve soil and water conservation, to manage price risks and to improve the competitiveness of small coffee farmers. The project was launched in the midst of the coffee rust crisis, a disease that devastated coffee production in the Central America. The need for recovery of plantations was urgent from early in the project. However, many of the same interventions to recover from coffee rust also contribute to climate resilience. To date, the productivity of coffee cultivation has increased by 123% among 1595 small-producer farms in three countries. Almost 4700 hectares are under cultivation using resilient water and soil practices in El Salvador, Honduras and Nicaragua. Greater efficiency in coffee mills has led to an estimated savings of 3 million liters of water. The important lesson learned is that while climate resilience was just one objective of this large project, it proved highly synergistic with other goals. Including increasing agricultural productivity, preserving the viability of smallholder farmers and saving livelihoods and providing a practical, sustainable and resilient response to the coffee rust crisis.

(iii) From climate vulnerable to 'climate strategic'

Climate change will mean grinding adjustments and dislocation for enterprises in many sectors. Some of these threats may be existential. Cities, settlements, enterprises and infrastructure along coasts may require relocation, dramatic redesign or abandonment. Crops that form part of multi-generational cultures, such as coffee, may cease to be viable in certain locations. Many types of supply chains will be disrupted, and the value of a large number of productive assets could decline.

Certainly, the scale and scope of climate adaptation and resilience will require public-sector leadership, particularly in developing countries. However, enterprises that take proactive measures to increase their resilience or to create new products or services, even in the face of uncertainty, can maintain their viability and create competitive advantages. Importantly, they can also create local capacity that can contribute to the public response to climate change. Lessons emerging from Proadapt underscore that even some of the smallest, least capitalized enterprises can improve their climate resilience with the right partnership. At the other end of the spectrum, climate resilience is also gaining the attention of global investor groups. Proadapt been part of this development in its mandate to foster knowledge, market intelligence and raise awareness.

The Nordic Development Fund, a co-financing entity of Proadapt, has approved support to part-finance the preparation and establishment of the Climate Resilience and Adaptation Finance and Technology Transfer Facility (CRAFT). CRAFT is the first global commercial investment vehicle to focus on technologies and solutions for climate adaptation and resilience in developing and developed countries. The targeted investment portfolio will include companies with resilience intelligence and resilience products and services that help private- and public-sector agents in assessing and managing the physical risks and impacts of climate change. This fund will enable the participation of a diverse set of investors, including concessional and commercial investors. CRAFT includes two separate investment windows, one each for developing and developed countries. A separate Technical Assistance Facility strengthens the support to investee companies in expanding technological capacity and solutions in developing countries (see https://lightsmithgp.com).

(iv) Entrepreneurship and private innovation in resilience: a private and public good

In developing countries, the public sector will continue to lead on climate adaptation policies and planning. Yet public resources alone are not sufficient, given the magnitude of this challenge. Private-sector actors engaged in resilience-building have useful experience and knowledge that can aid in the design and execution of National Adaptation Plans and related public programmes. For example, during the development of projects and knowledge products with Proadapt, the team worked with large beverage companies that possess extensive knowledge, analytics and metrics regarding water supplies, water quality and treatment, watersheds and related areas. Likewise, large agricultural companies and food companies also have extensive knowledge of crops, market conditions and the challenges of increasing the resilience of their own operations. Similar examples abound in other sectors. Engineering companies that design resilient infrastructure, construction companies building more resilient housing and buildings, and other private actors are sources of knowledge that could be useful for national planners in adaptation.

Entrepreneurship is a key indicator of the health of the private sector in most countries. Proadapt's own experience shows that climate risks can provide an entrepreneurial stimulus, even in some of the poorest and most vulnerable places. In the 'Proadapta Sertão' project in Brazil mentioned

previously, what began as an effort by six agricultural cooperatives to help poor smallholder families led to a business start-up to replicate this successful experience in the region and beyond. The business plan begins with the recognition that family farmers produce most of the food commodities in Latin America: 67% of milk, 30% of coffee, 80% of cocoa, 100% of açai, etc. Smallholder families are also among the most climate vulnerable groups, being highly exposed to variable and extreme weather events, yet having very limited means with which to build resilience.

To achieve these objectives, the Proadapta Sertão team has engineered a business platform called the MAIS Programme ('Modulo Agroclimatico Inteligente e Sustentavel') that helps farmers improve their production systems and become more resilient. The model improves resilience through a series of three basic interventions: (i) short-term actions to increase productive efficiency and generate enough cash flow to keep the family farmer in business; (ii) medium-term actions to reduce production fluctuations and introduce new technologies to help producers survive a heavy climate shock, such as a two-year drought that recurs every five years; and (iii) long-term actions to restore ecosystem services in the form of the local water cycle, soil conservation, reductions of external energy use and carbon sequestration, among many other objectives.

The MAIS programme is based on four integrated pillars: (i) a climate-smart agricultural production system that will be adapted to specific value chains and will consist of practical technologies, processes and management strategies; (ii) a customized technical assistance program that relies on a team of field technicians and a guide for farmers on a step-by-step process for implementation; (iii) a monitoring and evaluation methodology for MAIS implementation on the farms; and (iv) a farmer credit program, to help farmers access the capital they need to implement the MAIS programme.

The commercialization of the MAIS programme is at an early stage, but its designers have ambitions to replicate this model in Latin America and in other developing markets. This methodology also has the potential to be scaled in partnership with larger enterprises, a notable development given that its genesis was based on extensive work helping poor, climate-vulnerable smallholders on farms averaging two to three hectares.

The Jamaica National Foundation, part of the previously mentioned project in Jamaica, is promoting local entrepreneurship and start-ups related to climate resilience. It sees promising areas for small entrepreneurs and microenterprises in Jamaica and the Caribbean, in respect of: (i) climate smart agricultural solutions, such as supplying recycled water, drip irrigation systems and drought-resistant, organic seed varieties; (ii) water-use efficiency systems for the built environment, including low-flow toilets and taps, rainwater-harvesting, drought-tolerant landscapes and waterless products such as waterless car-wash cleaners; (iii) indigenous seedling propagation for reforestation and more resilient watershed management and flood control; (iv) resilient construction materials and practices and the retrofitting of structures to cope with extreme weather in low-income communities; (v) using renewable energy for back-up power supplies; and (vi) constructing baskets filled with stone or other heavy materials (known as 'gabion baskets') to stabilize slopes, shorelines and river banks in the face of climate risks, among other entrepreneurial opportunities.

(v) Market growth in climate-resilient solutions

While data on climate-resilient products and services have not yet been systematically collected, climate change will very likely increase the global demand for a wide range of private solutions to resilience. The following key growth areas for private resilience solutions have been identified by experts and stakeholders in the Proadapt network:

New water products and services: Climate variability and drought will increase the demand for water-efficient solutions, such as new types of metering, analytics, wastewater treatment, loss reduction, recycling and desalinization, among others.

Agricultural resilience: Climate change threatens agricultural productivity in many geographical environments, particularly in tropical countries. More efficient drip irrigation is needed, as well as the use of new analytics and micro-technologies in respect of 'precision agriculture,' drought-resilient seeds, storage and logistics, and tailored insurance to improve farmers' resilience in developing countries.

Resilience in Housing and the Built Environment: Increasing heat, humidity, flooding, storm surges and more extreme cyclonic winds are driving the demand for new building materials, monitoring systems and construction methods,

including more efficient ways to cool buildings and other innovations. A growing focus on resilient cities will spur new solutions in housing and the built environment, as well as new forms of urban planning.

Resilient infrastructure: Climate risks pose a serious challenge to the viability of transportation, water and energy infrastructure. The demand for new metrics, stress tests, climate-resilient materials, risk-sharing, flood maps and other solutions will increase. 'Green infrastructure,' in the form of restored trees, mangroves and wetlands, can help control flooding and storm surges, and will spur new forms of innovation in infrastructure. Public-private partnerships are becoming increasingly common in infrastructure projects, but they will require specialized technical and legal services to assure investors that climate resilience is being addressed in PPP design and delivery.

Resilience in Energy: Clean and renewable energy sources, such as wind and solar installations, both contribute to mitigation and are part of climate resilience. These installations and more conventional energy sources need resilient measures, particularly along coasts and in flood zones. Resilience also means adequate back-up power generation, distribution, micro-grids, storage and disaster recovery.

Health Care: Climate change is driving the expansion of vector-borne diseases and other public health threats. This will create a greater demand for new vaccines, pharmaceutical products, protection against mosquitoes and other pests, among other responses. In addition, extreme weather events will require the resilience of health-care facilities, such as rural clinics, to be increased.

Financial, insurance and investment methodologies and products: Debt instruments, such as green and climate bonds, could support investments in resilience. Credit-rating agencies now recognize climate change as a material risk, a fact that will incentivize climate resilience considerations in private decision-making. Catastrophe bonds have been successfully deployed as risk transfer instruments, and new types of climate risk insurance vehicles and risk assessment schemes are entering the market. Further, there is early and growing interest among venture capital and private equity investors in companies that produce climate-resilient products.

Increased climate change risk disclosure: The recent Task Force on Climate-Related Financial Disclosure and mounting concerns by large financial institutions and asset managers are increasing the pressure for climate risk disclosures to be made, thereby creating opportunities for firms that specialize in reporting and related activities. Currently, few companies, investors or lenders disclose their climate risks with adequate rigour.

Climate Analytics: One of the greatest impediments to private climate resilience is uncertainty over the timing, location and severity of climate-related costs. While the insurance and reinsurance industries have developed several probabilistic models of climate risks, these are usually proprietary and are not generally available to inform decision-making at the enterprise level. Climate analytics services that convert large amounts of climate data into business intelligence are evolving rapidly, often using machine learning and artificial intelligence to aid business decisions. Many of these products are being created by micro- and small enterprises.

4. Conclusions

Private innovation and investment in the area of climate resilience remains conceptually and empirically *terra incognita*. There is a need for greater research and awareness of private climate resilience given the enormity of this global public challenge. Currently, public authorities do not collect data on private resilience building systematically, while enterprises are not required to do so: '…national financial metrics would not capture private sector investment in climate-resilient development. While these private efforts would be worth capturing, data on them are scarce. Not only are climate-resilience activities often integrated into business activities, and therefore rarely stand-alone, the private sector also has no obligation to report on their climate resilience-related investments' (Väänänen, Dale, & Dickson, 2017). The opaque nature of private climate resilience may impede effective policy-making and perpetuate the perception of the private sector as short-sighted, uninterested or doing little in the way of practical resilience solutions.

Second, private solutions can protect many types of public and private assets, property and businesses from climate risks, which should in turn strengthen the global adaptive response, while also generating economic and social benefits. Little is known about the sectors, product groups and emerging technologies that represent the greatest private

opportunities for companies and investors. Further, how is the private sector dealing with the 'deep uncertainties' surrounding climate change and its impacts? What about financial metrics, models and indicators? How do investors and others monitor and evaluate investments in climate resilient projects? These and many other questions need to be explored (see Downing et. al. 2014).

Third, greater knowledge is needed to help businesses and investors effectively frame both climate-related *risks* and *opportunities*. Climate variability is the 'new normal,' and weather or natural-disaster models alone are no longer sufficient for a full understanding of enterprise risk. In the private sector, the awareness of climate risk is increasing rapidly. In December 2017, 237 companies with a combined market capitalization of over US $6.3 trillion endorsed the report of the Task Force on Climate-related Financial Disclosures (TCFD, 2017). The TCFD, created by the Financial Stability Board and chaired by the Governor of the Bank of England, has drawn up recommendations for the private disclosure of climate risks to help investors, lenders and others make sound financial decisions. Among the firms endorsing these recommendations are 150 financial firms, responsible for assets of over US$81.7 trillion, and companies from the construction, consumer goods, energy, metals & mining and transport sectors in 29 countries. The TCFD signaled to the private sector that climate risks are *material* and distinct from weather or natural disaster-related risks. It also emphasized the need for more conceptual development in this area.

Fourth, private awareness of climate resilience *opportunities* is much lower than the awareness of climate related *risks*. As already mentioned, almost none of the private innovation and market activity in climate resilience are labelled as such. Consequently, there is much to be gained by highlighting strategic opportunities as well as enterprises with innovative resilience solutions, both to foster scaling in the market and to spur broader demonstration effects. These efforts can also facilitate the identification of companies that are candidates for investment, credit, partnership or targeted assistance. Moreover, a better understanding of the contributions of the private sector to climate resilience adds a vital perspective to efforts to improve climate adaptation and resilience in developing countries. For example, the efficacy of National Adaptation Plans could be amplified through awareness of what local enterprises and the affiliates of non-national firms are doing in the area of resilient products and services.

The three-country study supported by Proadapt and the NDF is one example of applied research being used to shed light on the supply and demand of climate-resilient solutions in the market. The study focuses on two sectors, agriculture and transport, in three emerging markets: Colombia, the Philippines and South Africa. This inquiry will examine selected private resilience solutions on offer in these markets, the demand for such solutions, and the role of local policy and financial intermediaries in this process, among other variables. More work like this will be needed to shed light on the value of private climate resilience. Estimating the value of these resilience products and services will be a significant challenge. However, it is not unreasonable to hypothesize that the value of these solutions could exceed the current aggregate value of all public adaptation and climate resilience programmes. If the globe is to respond to the complex threat of anthropogenic climate change, it is time to bring the current and potential contributions of the private sector into full view.

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Developing the business case for adaptation in agriculture: case studies from the Adaptation Mitigation Readiness Project

Abstract

Agriculture-dependent Micro, Small and Medium Enterprises (MSMEs) are a vital part of developing country economies and are often the first to experience the impacts of climate change. Lack of access to finance is a well-known challenge to MSME growth and productivity in the agricultural sector in general. This study argues that the process of building a solid business case by MSMEs is a critical precursor to accessing lending systems or attracting financial investment opportunities for technological innovations systems that will support climate adaptation. The study draws on three cases from the Adaptation Mitigation Readiness (ADMIRE) project, focussed on innovative agricultural technologies, which assisted smallholders in adapting to climate change. A theoretical framework based on innovations systems was adopted to understand the structures and activities that contribute to the generation, diffusion and utilization of particular technologies. The results demonstrate that the landscape of business case development occurs through the co-evolution of various interdependent layers comprising technology, support institutions and socio-economic subsystems. Demonstrating proof of concept to both MSMEs and financiers is critical for generating the demand for adaptation among SMEs. Moreover, it is vital that appropriate resources are channelled towards business case development in the process of MSME adaptation planning, while also understanding the socio-cultural and governance challenges that, in combination with economic factors, shape the capacity of MSMEs to innovate and adapt to climate change.

1. Introduction

Micro, Small and Medium Enterprises (MSMEs) are a vital part of developing country economies and are disproportionately affected by the impacts of climate change. This is particularly evident in the agricultural sector, in which farmers and their crops are often the first to experience the impacts of climate-related extreme weather events. For agriculture-dependent MSMEs, adaptation to climate change is vital for ensuring business continuity. Climate change causes more uncertainty in MSMEs than in larger enterprises due to their limited capacity and access to resources (Sullivan-Taylor & Branicki, 2011).

Certainly, climate adaptation in agriculture is much more difficult to track and identify than climate adaptation in other sectors; agriculture itself is the result of a series of adaptation measures undertaken to domesticate and modify the natural environment. Disentangling an adaptation action resulting from the need for selective breeding or to adapt to climate change is not always easy. Indeed, farmers employ adaptation strategies for multiple purposes and benefits; in developing countries building resilience may be synonymous with both increasing yields and adapting to climate change. Perhaps much of the discussion on climate adaptation amongst agricultural MSMEs is simply a matter of framing.

Different approaches to engagement may be adopted when discussing adaptation in the agricultural value chain, from upstream (farmers, suppliers and intermediaries) to downstream (end-users, firms, export markets), which are both influenced by the socio-economic environment (e.g. government infrastructure, regulations, market access). However, in the case of agricultural MSMEs, options for engaging and responding are limited by finite resources, an inability to leverage themselves on the strength of key actors in the value chain and a lack of access to finance (Chittithaworn, 2011). Subsequently, studies often tend to focus on how to scale up financing for MSMEs from the perspective of the government, donors or financial institutions. However, most of the literature on financing for MSMEs in developing countries tends to overlook a vital step in the process of MSME capacity development itself. The article therefore argues that the development of a solid business case by the MSME is a critical precursor to accessing lending systems or attracting financial investment opportunities for technological innovation systems that will support climate adaptation and ensure business continuity. By unpacking the business problem or opportunity by assessing the various risks, possible technical solutions, impacts on operations and organizational capacity to deliver the outcomes, MSMEs should be able to expand their opportunity structures in accessing new finance streams to support adaptation. Klein, Adams, Dzebo, Davis, & Kehler Siebert (2017) highlights that research on how to build a business case for adaptation has a role to play in informing debates within the business community, which may at times require new methods of engaging businesses with communities and challenging norms in respect of how gains and returns on investments are defined.

In support of its key argument, this article presents three diverse cases of MSME business development from Ghana, Jamaica and Peru forming part of the Adaptation Mitigation Readiness (ADMIRE) project, funded by the Danish Ministry of Foreign Affairs and implemented by the UNEP DTU Partnership (UDP) in collaboration with local partners. All three cases were underpinned by the requirement to develop strong business cases to attract new opportunities for investments in adaptation. Each business case represents a new adaptive response to agriculture affected by climate change via the introduction of innovative technologies, which were facilitated through various financing mechanisms and support structures. Technological capacities benefit MSMEs in several ways, enhancing efficiency, reducing costs and broadening market share, both locally and globally (Bouazza, Ardjouman, & Abada, 2015). Financing of technological innovations is thus one of several approaches to adaptation amongst MSMEs, which can contribute to maximising profits. The article first presents a guiding conceptual framework for examining the three cases presented, then highlights the challenges faced by agricultural MSMEs, followed by a description and a discussion of the three cases, and concluding with a set of key recommendations for MSMEs to develop strong business cases to facilitate access to lending systems.

2. Innovation Systems Framework

A common thread binding together the three ADMIRE cases presented here is the role of technology in both adaptation and mitigation. We thus draw on the innovations systems theoretical framework, which provides a heuristic for understanding the arrangement of structures and activities that contribute to the generation, diffusion and utilization of a particular technology (Twomey & Gaziulusoy, 2014). It does this by unpacking the various structures that support the functioning of technological innovation systems, as

Table 1. The building blocks of a technological innovation system (TIS) (Twomey & Gaziulusoy, 2014)

System Function	Description	Typical events
F1. Entrepreneurial activities	The presence of risk-taking entrepreneurs is essential, as they translate knowledge into business opportunities by performing commercial experiments.	Commercial projects, demonstrations, portfolio expansions.
F2. Knowledge development	R&D and knowledge development, mostly for emerging technology, but also for markets, networks, users etc.	Studies, laboratory trials, pilots, prototypes developed.
F3. Knowledge diffusion / knowledge exchange	Using networks and other interactions to facilitate the exchange of knowledge between all the actors involved in the TIS.	Conferences, workshops, alliances between actors, joint ventures, setting up of platforms or branch organizations.
F4. Guidance of the search	Activities within the TIS that shape the needs, requirements and expectations of actors with respect to their (further) support of the emerging innovation.	Expectations, promises, policy targets, standards, research outcomes.
F5. Market formation	Activities that contribute to the creation of a demand for the emerging technology.	Regulations supporting niche markets, generic tax exemptions, 'obligatory use'.
F6. Resource mobilization	Facilitating access to financial, material and human capital.	Subsidies, investments, infrastructure developments.
F7. Support from advocacy coalitions	Forming advocacy coalitions to counteract institutional inertia by urging authorities to reorganize the configuration of the system.	Lobbies, opinion pieces, advice.

outlined in Table 1. Using technology as the central focus of our cases, we aim to understand how these key structures can facilitate innovation while simultaneously supporting the development of a business case for adaptation.

3. Defining and financing agricultural MSMEs

While there is no standard definition of MSMEs, this article defines agricultural MSME's as 'enterprises engaged in agriculture-related activities such as farming/production, input supply, trade, and processing' (IFC, 2011). However, it is important to acknowledge that what is defined as 'small' or 'medium' in the context of one country may not hold true in another, particularly in the agricultural sector, which is highly heterogeneous. Often MSMEs are classified according to number of employees and annual turnover, with micro-businesses having fewer than ten employees and medium-sized ones having fewer than 250. In the European Union, the maximum size is considered to be 250 employees and in countries like the United States, Mexico and Papua New Guinea it is 500. Adaptation is defined as 'the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities' (IPCC, 2013).

In many developing countries, the agricultural sector largely involves subsistence or family-led operations, and it is often a very heterogeneous group, with varying plot sizes, production capacities, resources and levels of expertise (IFC, 2012). A significant proportion of agricultural MSMEs in developing countries are also found in the informal sector, where they fall outside the purview of national policies and regulations, adding an additional barrier to developing viable business models and unlocking access to finance (OECD, 2008). Lack of access to finance is a well-known challenge to MSME growth and productivity in the agricultural sector in general, but more specifically for the 'micro'-end of MSMEs. The small size and heterogeneous nature of many agricultural MSMEs causes financial organizations to behave more cautiously when lending to them. Low population densities and remote locations lead to high transaction costs, which are often compounded by underdeveloped infrastructure, immature markets and price volatility linked to seasonality

(IFC, 2012). Many financial institutions, including local banks, lack experience in lending to agricultural MSMEs. Instead, they try to hedge these perceived risks by charging MSMEs high interest rates and demanding high collateral and loan guarantees, thus locking many smallholders out of the credit market (Bouazza et al., 2015). It is often difficult for financial institutions to justify investing in what is seen to be a high-risk sector with large uncertainties. Additionally, MSMEs often lack the initial investment capital or necessary collateral to secure a decent loan if an investor does show an interest.

Developing a strong business case for agricultural adaptation

Agricultural MSMEs can struggle to maintain consistent yields, quantify their inputs and estimate a return on investment within a given margin. Such challenges often make it difficult for them to develop a strong business case for investment, even in instances where there is a clear requirement for climate adaptation. Moreover, agricultural MSMEs often struggle to take advantage of available investment opportunities that are targeting them due to knowledge, capital and technological constraints (CDKN, 2013).

In building business resilience, the development of a strong business model for agricultural MSMEs is vital and in many instances may be the key to unlocking investment. Vermeulen and Cotula (2010) define a business model as 'the way in which a company structures its resources, partnerships and customer relationships in order to create and capture value'. This can take many forms, with large-scale farming drawing on local landholders, or better incorporation of smallholders into the value chain through cooperative organizations. Ultimately, it is contingent on the mobilization and utilization of resources, in which MSMEs draw upon their internal structures to overcome the types of constraints listed above, such as a lack of know-how or capital. Indeed, building a business case for adaptation is a mutli-faceted endeavour, including the need to develop and support other mediating factors such as establishment of social networks, policies/governance structures or enhancing the capacity of MSMEs to use climate information for decision-making. Concurrently, a demand from MSMEs for technological innovations is vital if a business case for adaptation is to be generated and subsequently financed.

Lending system specification

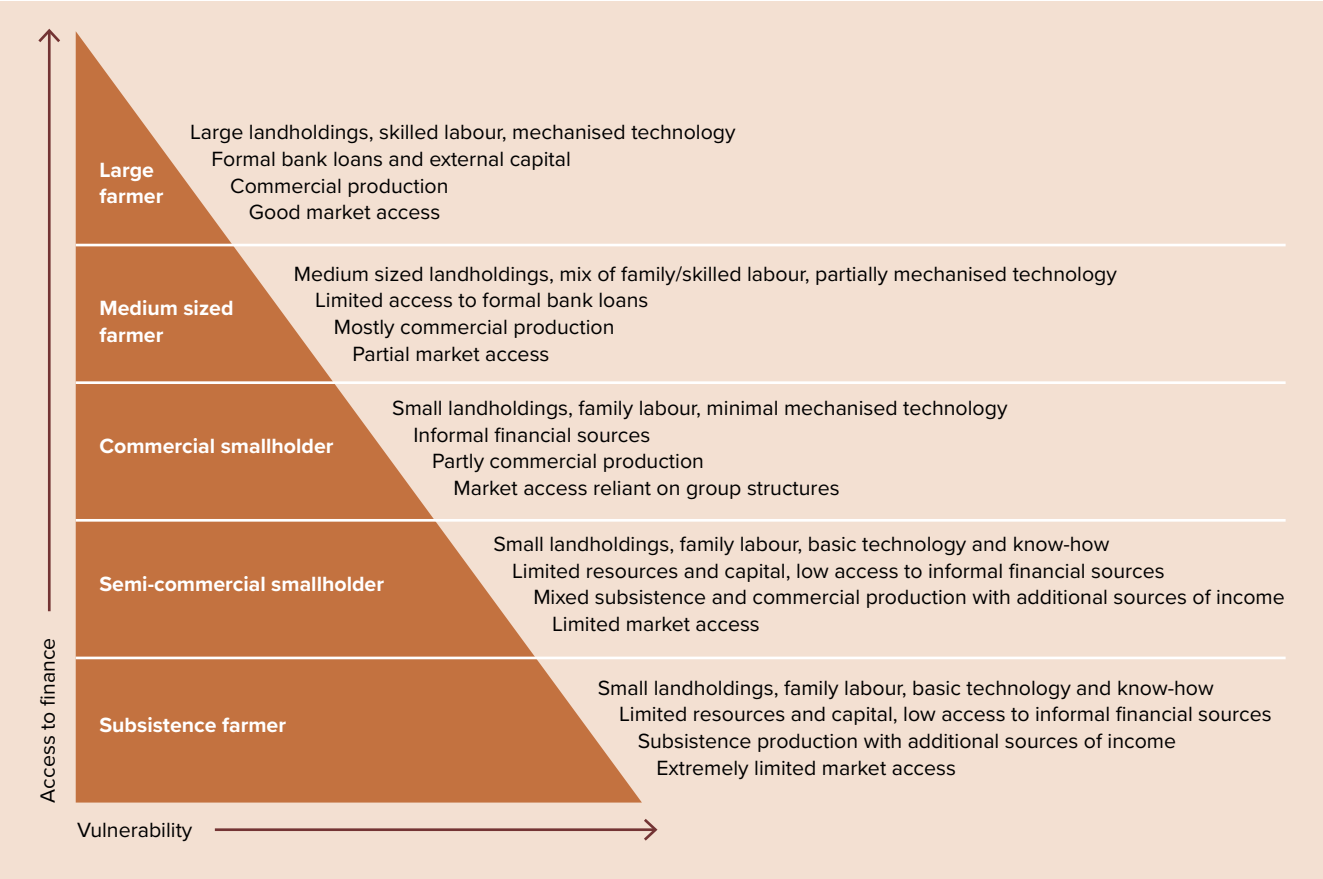
Many models exist for classifying and categorizing different lending systems or approaches within the agricultural sector. These range from loose to tight value chains, direct financing of farmers and financing movable assets to cooperative financing. Moreover, agricultural MSMEs will often utilize many different lending approaches and credit lines at once, for example, by leasing moveable assets (such as equipment) using an advance payment from an end-buyer higher up the value chain (Vermeulen & Cotula, 2010; IFC, 2012). However, to examine the three cases and draw more general and widely applicable conclusions, this article zooms in on three lending systems: direct smallholder lending, implicit lending via cooperatives and value chain financing.

Direct smallholder lending, in which smallholders access loans and financial services directly from financial institutions, is the most traditional and straightforward model (Vermeulen & Cotula, 2010). However, this model often requires that MSMEs can produce reasonable collateral, are requesting a large enough loan to justify the transaction costs, and can demonstrate creditworthiness based on past transactions – all requirements which effectively exclude semi-commercial smallholders and smallholders from fully utilizing this lending system (Vermeulen & Cotula, 2010).

In the case of *implicit lending systems via cooperatives*, a bank lends to an aggregator organization, such as a farmers' association or cooperative, instead of to farmers directly. Here the collective organization is the borrower, and the pooling of resources into a central fund forms the basis of the business model (IFC, 2012). This model is often advantageous for smallholders who are at the micro-end of MSMEs, as it has the effect of reducing transaction and administration costs for both bank and borrower. Moreover, it provides a model in which banks can hedge against high risks, as members of the collective can be guarantors for each other. In addition, it allows farmers a stronger platform for negotiating preferential rates when contracting suppliers and negotiating contracts with end-buyers.

Finally, with value chain financing, key actors in the value chain rely on their business relationships and interdependencies for their main sources of finance (IFC, 2012). Practically speaking, this means that finance flows between value chain actors, with agreements between buyers and suppliers forming the basis of the business model and making up the majority of financial transactions. Financial

Figure 1. Farmer segmentation and associated vulnerability and access to finance among different categories of MSMEs (IFC, 2012)



institutions can also set up flows into the value chain, but these often rely on proof of contracts between suppliers and buyers to secure loans.

Farmer Segmentation

The following section sets out a framework for defining and categorizing agricultural MSMEs based on the conceptual framework developed by the International Finance Corporation, which provides a model of farmer segmentation and their delineation of lending system specifications (IFC, 2012).

The IFC (2012) framework (see Figure 1) classifies agricultural MSMEs into five key groupings covering a range of characteristics and accounting for structural differences in farm sizes, income and labour requirements. These categories are large farmers, medium-sized farmers, commercial smallholders, semi-commercial smallholders and subsistence farmers. While this is something of an arbitrary exercise given the heterogeneous nature of most smallholders, it assists in identifying which financial services and business models might be most useful for each market segment and allows financial institutions to understand the risks and limitations better when developing financial packages for the agricultural sector (ibid.). Moreover, this system of classification allows agricultural MSMEs to understand where they are placed in the wider agricultural value chain and what financial services are more readily available to them, thus clearly defining their business case. Figure 1 also indicates that access to finance is often directly proportional to the size of the landholding and scale of production where vulnerability is inversely proportional to the size of the landholding and scale of production. Subsequently, the more 'micro' an agricultural MSME, the

more vulnerable it is to covariate shocks making establishing a business case for adaptation to climate-related risks even more vital.

4. Case descriptions and discussion

The following section adopts both the framework presented in Figure 1 and the various lending specifications discussed previously to analyse the three cases presented here. It seeks to identify the enabling factors needed to establish a strong business case to attract financial investment opportunities (see Table 2). The three cases aim to ensure food security, sustain livelihoods and feed future generations by empowering farmers to be climate-resilient. It is important to note that each case draws on support and funding from the ADMIRE programme implemented by UDP and provides examples of how MSMEs can leverage public funding to generate private capital and develop strong business cases for adaptation. The projects in Ghana and Jamaica have both completed their pilot phases under the ADMIRE programme and continue to progress and expand in country through new funding mechanisms. The Peru case is currently at the final stage of its pilot phase.

4.1 Rehabilitation and renewal of coffee plantations in Peru

Coffee remains a key agricultural export commodity in Peru. Covering an area of more than 425,000 hectares (ha), the Andean Amazon ecosystem is home to 95% of Peruvian coffee producers. The entire coffee sector comprises more than 223,000 producers, of whom 85% are small-scale farmers possessing average size land holdings of three hectares. However, the agricultural sector also makes a key contribution to the country's GHGs emissions of 28%. Technology is out-dated, plantations being on average more than twenty years old, and new coffee-farming areas are increasingly expanding and encroaching into primary forests. Such challenges, coupled with future projections of the development and expansion of the coffee sector, have led the Peruvian Government to prioritize the development of a Nationally Appropriate Mitigation Action (NAMA) for the sector, with a focus on seven regions in the Amazon. NAMAs are an outcome of the UNFCCC process in which developing countries aim to reduce emissions relative to 'business as usual' emissions through various technology, financing, policy and capacity-building initiatives. Peru's coffee NAMA aims to re-direct the growth of coffee production from expansion and encroachment into natural forests to the intensification of existing farms and abandoned lands. This will be brought about through investments in climate-resilient, low-carbon, high-yield technologies which have co-benefits for both adaptation and mitigation. This process will be facilitated through loans, which are tied to farm-level environmental commitments. NAMA implementation aims to build resilient livelihoods for more than 200,000 coffee producers by increasing productivity and expanding markets while making significant reductions in carbon dioxide emissions by 2025.

The ADMIRE project initially targeted 6,000 smallholder producers, divided into three categories: very small producers, small producers and medium-small producers. Very small producers were characterized as having a hectare of land or less, small producers between two and four hectares, and medium-small producers five to ten hectares. One of the key objectives of the ADMIRE project was to create the necessary financial frameworks for the coffee NAMA, thereby building the business case for private investment in the technical implementation of the NAMA through investments in carbon-friendly technologies and/or practices capable of complementing Peruvian state efforts. The financial frameworks included the development of a financial tools/model, and an economic evaluation of

Table 2. Classification of the three cases according to type of agricultural SME and lending systems for business case development

Case Study	Lending specification	Farmer Segment
Peru	Implicit lending via coops	Subsistence farmers
Ghana	Value chain financing	Semi-commercial farmers
Jamaica	Direct smallholder lending	Commercial smallholders

low-emission alternatives for coffee production to inform the various options for introducing low-carbon methods to coffee production. However, a key barrier preventing Peruvian smallholder farmers from investing in and adopting such technologies over the long-term is the lack of security over formal land tenure. In addressing this barrier, a secondary objective of the ADMIRE project was to develop appropriate administrative tools (i.e. procedures and guidelines) to facilitate the transfer of rights to use the land for the development of agroforestry systems.

The financial model and tools were designed to link financial institutions and farmers by demonstrating the business case for investing in low-emission technologies allowing farmers to adapt and/or mitigate climate impacts. Specifically, allowing both farmers and investors to build distinct rehabilitation or renewal scenarios and the associated capital required to convert their production processes under these scenarios. For example, producers are able to analyse farmers' costs and revenues associated with two proposed bundles of high-yield, low-carbon technologies for established plants or pre-established plants. Cash-flow scenarios were also developed using various loan parameters to demonstrate the viability or non-viability of the proposed investments and associated risks (e.g. loan defaults). A key finding was the need for technical assistance programs under the NAMA to collect spatially-explicit farm-level information to reduce loan delinquency and lender risk. A key recommendation of the study was that the NAMA should focus on medium-smallholders with two to fifteen hectares, as the transaction costs are unviable for farmers with only a hectare of land.

Limited access to finance is a key constraint on farmers adopting new environmentally friendly technologies. In addition, smallholders are not organized entrepreneurially, most growing and marketing their products independently, only a small percentage belonging to cooperatives or other producer associations. This hinders participation in the wider market system, as well as access to training, technical assistance and credit. The results from the financial and economic modelling indicate the need for better insertion of smallholders in the national and international market through the encouragement of producer organizations (i.e. cooperatives) and linking these to other networks in local coffee-cultivation value chains. In addition, membership in cooperatives would reduce loan default risks, making it possible to extend preferential loan conditions to such producers or those attached to other organizational modalities along the value chain.

The economic analysis comprised desktop and qualitative interviews to compile a set of low-emission alternatives for coffee production to inform the various options for introducing low carbon methods of production and using data from 180 pilot plants in Peru and elsewhere in Latin America. It also calculated the costs of various low-emission alternatives to coffee production and compared them to current costs of production. The results highlighted the need for a comprehensive approach to financing requiring the integration of technical assistance schemes related to the marketing of production, advice on processes that may need modification or updating, and extension services, which may be addressed through the creation of cooperatives or offered through financial institutions. Among the administrative tools to be developed are subnational procedures to integrate the so-called 'use cession of land in agroforestry systems' into the forestry law, which will provide small coffee producers with the legal stability to invest in low-carbon, climate-resilient technologies.

This case example demonstrates the need to address both financial and governance aspects in building a business case for adaptation. The two components are complementary, enabling the identification of climate financing opportunities and new associations within the value chain that allow farmers to profit from investing in low GHG emission technologies and climate -resilient techniques that enable farmers to adapt to expected impacts of climate change by increasing their yields.

4.2 Mobile agricultural extension services in Ghana

The agriculture sector dominates the Ghanaian economy in terms of income, employment (comprising 60% of the labour force), food security and export earnings, but it is highly vulnerable to climate change and variability, particularly from variations in rainfall patterns. Although Ghana is one of the world's leading producers and exporters of cocoa beans, it is projected that increased temperatures from climate change will have severe impacts on the sector. Ghanaian agriculture is dominated to over 90% by smallholders with a national average landholding of 3.2 hectares per farmer. Smallholders rely heavily on rainfall and have limited access to irrigation facilities. This is exacerbated by the increased uncertainty in rainfall patterns, which are currently distorting farming cycles, lowering yields and creating a cycle of hunger and

poverty. In an effort to transform the structure of the economy and alleviate poverty, the government has stated that it regards agricultural modernization and increasing smallholder farmers' market orientation to be a key step in meeting this goal.

Over a two-year period, the ADMIRE project targeted approximately six thousand semi-commercial smallholders, or 0.1% of the total farming population, in nine regions through six local value-chain actors representing financial institutions, NGOs and outgrowers. The crops that were chosen included maize and rice, which remain two of the most consumed staple crops in Ghana, whilst cocoa being the country's main cash crop. The ADMIRE project aimed to build resilient livelihoods and maintain productive crop yields under climate change through the introduction of a mobile phone-based agricultural extension service and reliable weather information provided through a local technology company, VOTO Mobile Technologies Limited.

Ghana's agricultural extension officer-to-farmer ratio is 1:2000, representing a thinly stretched service restricting the delivery of key extension services. It is estimated that over 95% of smallholders suffer a huge agricultural extension gap resulting in lower yields. However, there exists a high rate of ownership of mobile phones among smallholders, with most owning more than one phone. This high level of ownership created an opportunity for VOTO Mobile to leverage funding from UDP to provide mobile interventions through an Interactive Voice Response (IVR) platform that bridged the gap between farmers and extension officers. VOTO Mobile provided weekly extension services on agronomy, market prices and links, coupled with weather updates via voice messages in the farmers' local language in an effort to increase farmer yields and increase their climate resilience. Agronomic tips were also issued, covering site selection to harvesting and post-harvest handling, market prices focused on community, district and regional markets, environmental protection tips on bush burning and tractor maintenance tips, while weather forecasts were issued in a timely fashion for at least five days of each week. This free service provided the first opportunity for many farmers to acquire new technical information about agricultural practices (e.g. the correct time to apply fertilizer and other agrochemicals), change their behaviour and make informed decisions about farming practices. In addition, many of the financial institutions involved used the service to send out reminders to farmers about loan repayments and thus, reduce farmer default rates and subsequently increase their borrowing capacity.

VOTO Mobile recruits farmers through value-chain actors with an existing relationship with the farmers: for example, NGOs are indirectly connected to the smallholders, who provide access or informal connections to potential markets, traders and buyers for their produce. The value-chain actors who partnered on the ADMIRE project received the service pro bono, as a trial phase from VOTO Mobile to their farmers. Often value chain actors spend a considerable amount of resources finding and grooming farmers and farmer's groups. Mobilizing the value chain actors also ensured that VOTO Mobile could easily demonstrate the benefits of the mobile service intervention to their customers, as well as avoiding the need to chase overdue service fees from farmers directly. This economic model is unique, as the mobile extension services that are currently available in Ghana often require farmers to pay directly to the service providers rather than to value-chain actors.

Due to the pilot nature of the project, VOTO conducted surveys before and after intervention to demonstrate to both farmers and value-chain actors the key benefits, limitations and viability of the intervention. Results indicated a 30% to 80% increase in yields per acre, which translated into US$75 to $125 in revenue. The variations in yields were due to the extent of uptake of the intervention information by farmers, as well as variability in weather patterns. Since the project ended, a few of the farmers that were part of the pilot phase have now increased their farm size due to increased yields. At the end of the intervention, many of the farmers with over ten acres per season felt that the benefits outweighed the costs of the service. Farmers who benefited from the intervention also promoted the service through their farmers' groups and family networks, thus increasing demand for the service still further.

In comparison to farmers without access to the mobile extension service, the service prevented farmers from losses associated with climate change, despite the higher costs associated with farming due to the adoption of new interventions such as the use of various agrochemicals, ploughing techniques and improved seed varieties. A few farmers made losses due to reduced rainfall, while others only managed to break even. Some of the barriers to accessing the mobile service included the need to use a recorded voice service rather than text messaging, as it was

realized at an early stage of the project that many farmers were illiterate. In addition, a few value-chain actors initially felt that the service would be too technically difficult for their clients to understand. Nonetheless the interventions allowed farmers to generate profits through increased yields and improved understanding of agricultural practices. This enabled farmers to leverage this information to build a strong business case for accessing credit (e.g. to purchase a tractor) or other resources available through value-chain actors (e.g. microfinance lenders or NGOs).

Since the completion of the ADMIRE project, several value-chain actors have continued to extend VOTO's mobile extension services to their clients. This has required farmers to pay a subsidized fee of US$4 per season for agronomic advice, market prices and weather information. If farmers require specialized information, for example, related to tractor-servicing, then this is charged at an additional cost. Farmers also have the choice of accessing the service through cooperatives, which enables the costs to be shared and thus reduces the cost per farmer. This case has demonstrated how communities can adapt to both current climate variability and expected climate change through improving productivity.

4.3 The adaptive agricultural programme in Jamaica

Jamaica is increasingly vulnerable to the impacts of climate change, particularly in the agricultural sector, which is impacted by cyclones, floods, sea level rise and more frequent record-setting droughts (Mitchell et al., 2016). Such impacts have led to shortages in food production, price volatility for staple crops and increasing reliance on agricultural imports from the United States. Many agricultural MSMEs are unable to cope, as they often lack resources or capital.

The Adaptive Agriculture Programme (AAP) run by ADMIRE partner INMED Partnerships for Children sought to address the ability of Jamaica's agricultural sector to adapt to climate change through the introduction and scaling up of a simplified and cost-effective form of aquaponics system. This allowed agricultural micro-level MSMEs, which contributed 90 per cent of domestic agricultural production, to diversify their livelihood strategies and subsequently decrease their risks by employing a new form of production. With ADMIRE support and funding, AAP was able to prove the efficacy, cost-effectiveness and profitability of aquaponics technology in the Jamaican context, thereby building a strong business case for financial institutions to invest in this technology.

Aquaponics technology is an intensive, resource-efficient food-production technique whereby aquaculture (fish-farming) and hydroponics (soilless crop production) are combined in a closed system that conserves water, space and inputs (e.g. reduced pesticide and fertilizer use), while delivering enhanced yields of 3.4 times more in comparison to a traditional system on a similar land area. The system recycles water and thus reduces water consumption by approximately 80-90% per unit produced. Moreover, the crops are grown in an elevated position, reducing risks from flooding, while the risks from hurricanes are countered through a reduced growing cycle. While aquaponics itself is a huge industry in places such as Israel and the USA, it is a fairly new and untested technology within the Jamaican landscape (Love et al., 2014). In introducing this technology into Jamaica, the AAP sought to develop a more cost-effective and accessible system for Jamaican farmers.

However, despite the associated benefits of this system and its clear added value in respect of climate resilience, proving the investment potential of a new and previously unproven technology represented a key challenge for the AAP. Limited awareness among agricultural MSMS with respect to the technology was also a barrier to its uptake. MSMEs often perceive investing in a new technology with high upfront capital costs of USD 17,500 per system, to be repaid through profits over four years, as inherently risky. Moreover, in Jamaica financial institutions are suspicious of lending to cooperative groups and prefer the more traditional model of lending directly to MSMEs. Given the limited capital, time and resources of agricultural MSMEs, it was a challenge both to establish and to operate an aquaponics system that represented the returns on investment given optimal conditions (i.e. the yields for a given range of suitable crops, within a certain season, at the average market price). This required an awareness-raising campaign; calculation of the upfront capital required for building and implementing the system; detailed and regular monitoring of all system inputs and outputs; a detailed analysis of market conditions; and a post-hoc comparison of data from the aquaponics system to existing data on traditional systems. It was found that the yields from the two cash crops that were piloted, tomatoes and peppers, produced four times more annual profits than those of conventional farming systems. Establishing this solid technological baseline was a key consideration whereby

financial institutions could understand the robustness of the technology and estimate their returns on investment over a given period. However, undertaking such a methodological exercise is an intensive process that requires additional time, labour and resources than those typically possessed by agricultural MSMEs, who are often time- and resource-poor. Without external support from the ADMIRE programme, addressing such a barrier would most likely have been an impossible exercise for most MSMEs, and the dissemination and uptake of such a technology a missed opportunity. Moreover, ADMIRE was able to facilitate engagement between key stakeholders (e.g. MSMEs, financial intuitions, government, equipment suppliers and buyers) to raise awareness and establish new partnerships. The project also generated new markets in which the MSMEs could supply directly to hotels and restaurants due to the higher quality crops (e.g. organic produce) that were being produced.

In addition, financial institutions required assurance against long-term risks for such a new technologies in the form of on-going technical assistance. The Development Bank of Jamaica and other local financial institutions expressed the need for assurances that the AAP would assist in the construction of aquaponics units to meet quality assurance standards, as well as continue to provide training and capacity-building over a three-year period to ensure that MSMEs investing in the technology were provided with technical supported. The development of such a training and support facility became a major barrier to scaling up the technology , as it created the need for additional investment capital that MSMEs willing to invest in aquaponics did not have. The revenues for such a facility had to be sourced externally by exploiting grants or subsidies, as adding an additional debt burden to agricultural MSMEs was not feasible given the high upfront capital costs of the technology. After proving the feasibility of the technology, AAP was able to secure a three-year grant from the Inter-American Development Bank to establish a training and capacity-building centre to provide on-going support to agricultural MSMEs. Subsequently, this allowed AAP to negotiate preferential rates with local financial institutions such as the Development Bank of Jamaica on loans to MSMEs investing in the technology, thereby overcoming capital investment barriers. Approximately 150 new MSMEs have now been enrolled in the upscaling phase to be trained in the climate-smart aquaponics technology, and 120 have been linked with strategic business partners in order to access credit. In addition, various local financial institutions have also been enrolled in the training in order to provide them with an understanding of the technology and its applications. It is estimated that an average of US$17,000 will be earned by MSME participants through sales of their cash crops. This case has demonstrated how the introduction of new technology as an adaptation intervention to current climate change, enabled small holders to increase productivity and make profits. Aquaponics may only be a sustainable adaptation option if sufficient water is likely to continue to be available in the future.

5. Conclusions

Recently the private sector has been engaging increasingly with climate change debates, exploring pathways in which the sector can build resilience and ensure business continuity under various climate risk scenarios. Often this attention has been limited to the larger businesses, but an emerging body of scholarship has focused on identifying elements that support small businesses in building up their capacity to adapt (CAG Consultants, 2011; Ingirige & Jones, 2008; KPMG, 2016). This paper has contributed to advancing our understanding of building the climate resilience of MSMEs by drawing on three cases from the ADMIRE project based on agricultural technologies, which assisted smallholders in adapting to climate change.

Using a bottom-up approach, the cases demonstrated how agricultural MSMEs can build their business cases to access finance in their efforts to adopt innovative technologies and associated practices that mitigate climate risks while sustaining livelihoods. In all three cases, the results highlighted the significance of developing a business case as part of the process of enabling MSMEs to adapt. It was evident that the landscape of business case development was informed by the co-evolution of various interdependent layers comprising technology, support institutions and socio-economic subsystems. The ADMIRE projects provided an opportunity to understand some of the key underlying factors and challenges confronting business case development related to agricultural technologies and their supporting processes. The three cases highlight the need to integrate climate risk assessment as a key component of a business case for financing adaptation initiatives. Moreover, generating a demand from MSMEs for technological innovations is vital if a business case for adaptation is to be developed and subsequently financed. The ADMIRE project facilitated the proof of concept and thus, facilitated the demand for adaptation among agricultural MSMEs.

Specifically, the results suggest that 1) technology development and proof of concept, 2) training and institutional support, 3) value-chain mapping and 4) capital investment are all critical enabling factors supporting business case development for purposes of adaptation. In all three cases, resources and time had to be invested at the outset in proving the technology, which can be linked to the knowledge development phase outlined in Table 1. In the absence of this phase, vital supportive data required to prove returns on investment for potential financial institutions, farmers and other supporting intuitions within the value chain might not have been possible. This phase also enabled critical information to be gathered while concurrently generating awareness of potential climatic impacts on MSMEs. In the case of Peru, developing financial and economic modelling tools generated the data necessary for these various actors to make decisions about whether to invest in low emission technologies. In addition, this phase created knowledge related to potential markets, networks and users of these technologies. It is thus vital that planned adaptation initiatives targeting MSMEs allocate adequate funding to support 'knowledge development' activities, including the monitoring of pre- and post-intervention benefits as part of business case development. The results indicate that this process may also require access to specialist skills in the form of engaging external consultants or academics with good understanding of the local context.

As outlined in Table 1, training and institutional support can catalyse knowledge diffusion and knowledge exchange and create a forum for generating shared values. All three cases highlighted the role of various support agencies (i.e. formal and informal) and their role in harnessing skills and knowledge diffusion to support business case development. In the case of Jamaica, establishing a specific training centre and associated programmes for aquaponics systems targeting smallholders and financial institutions was a key factor that contributed to business case development and attracted new financing streams. In Ghana, VOTO Mobile played a critical role in training and sharing knowledge about sustainable agricultural practices among smallholders, delivered in the local dialect. It was through such interventions that farmers realized the value of investing in mobile extension services to boost yields. The results indicate that policy-makers and adaptation planners should seek opportunities to support contextually relevant and locally tailored training programmes for MSMEs related to business case development that can complement the proof-of-concept phase.

The results highlight the complementary nature of value-chain mapping and capital investment for business case development, as reflected in Table 1 under 'guidance of the search', 'market formation' and 'resource mobilisation' functions. In all three case studies, value-chain mapping enabled the identification of various intermediaries who were valuable in generating awareness of the technology, as well as in providing a vital link for MSMEs in accessing financing. In both Ghana and Peru, working through cooperatives enabled smallholders who were previously disconnected from the market to access new opportunities to promote their products, form advocacy coalitions to challenge various institutional barriers, increase revenues by improving marketing efficiency , increase their credit worthiness and access new sources of credit. Strengthening value chains by, for example, forming new networks also contributed to ensuring resilience and business continuity under various climatic and other stressors. Moreover, the results showed that financial institutions and investors often make decisions on extending loans to MSMEs based on their immersion in the value chain. This often requires an overview of the entire value chain, which may be fragmented or loose (as compared to tight value chains). It also generates opportunities for financial institutions to tailor or introduce products capable of generating new income streams via investments related to adaptation. The results suggest that it is valuable for adaptation initiatives to mobilize financial institutions at an early stage of a proposed project to obtain their buy-in and identify opportunities for new financial products that could help build climate resilience of MSMEs over the long term.

Certainly, this study has demonstrated the importance of developing a business case for MSMEs to adapt to climate change and that this is a long-term process. Moreover, the results suggest that donors and other agencies supporting MSMEs need to direct appropriate resources towards this vital step in the process of adaptation planning, while also being cognisant of the need to understand the socio-cultural and governance challenges that, in combination with economic factors, shape the capacity of MSMEs to innovate and adapt to climate change.

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SECTION B

Enabling instruments and mechanisms for promoting MSMEs' adaptation action

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MSMEs, climate change risks and insurance: reflections on the use of insurance for climate adaptation

Abstract

While there is growing evidence of the challenges that climate change presents to MSMEs, it remains unclear if and how MSMEs are responding. The adaptive capacity of MSMEs is often low, and few appear to have embraced climate risk management as a business tool. One mechanism that could facilitate MSME's efforts to prepare for and cope with climate risks is insurance. Currently promoted by donors and many governments as a promising mechanism to establish climate risk management practices, the uptake of climate risk insurance remains low among MSMEs across the world due to a range of demand and supply challenges. This paper provides an overview of the use of insurance by MSMEs, drawing on recent examples from both developed and developing countries. While insurance has the potential to facilitate risk awareness, business continuity efforts and future planning by MSMEs, it can only drive adaptation if it is integrated into a broader adaptation strategy that triggers risk-reducing behaviour, rather than creating a false sense of security. The paper concludes with a reflection on how to harness the adaptation potential of insurance for MSMEs.

1. Introduction

Micro, small and medium enterprises (MSMEs) are the lynchpin of the world economy, accounting for approximately 80% of global economic growth (Gandhi, Gupta, & Sethi, 2013). Businesses ranging from one-man shops to medium-sized companies are key pillars for employment and underpin the value chains in most economic sectors across developed and developing countries. While their economic importance is undisputed, there is surprisingly little understanding of how they can be supported in the face of climate risks, which provide both an existential threat to many MSMEs and exacerbate the existing risks they face (e.g. by causing supply chain interruption). The little we know tends to be limited to the primary sector, particularly agricultural MSMEs, due to their direct exposure to climate risks, while for MSMEs operating in the manufacturing or services sectors, far less information exists about the impacts of a changing climate and MSME efforts to address them (Averchenkova, Crick, Kocornik-Mina, Leck, & Surminski, 2016).

The use of financial instruments, such as insurance, is increasingly seen as an important component of efforts to enhance climate resilience, with the IPCC stating that '…risk sharing and transfer mechanisms at local, national, regional and global scales can increase resilience to climate extremes' (IPCC, 2012). In the case of MSMEs, insurance may support entrepreneurship and greater development potential for businesses by allowing them to focus on positive risk-taking, as well as potentially increasing their chances of receiving investments or securing commercial contracts (Warner et al., 2010). At the same time, there is evidence that a poorly designed risk-transfer mechanism can create a false sense of security or lead to moral hazard (i.e. the tendency for policy-holders to partake in risky behaviour because they have insurance coverage) and reduce incentives for direct risk reductions (Ranger et al., 2011).

This paper explores the role of climate risk insurance as a possible mechanism to facilitate adaptive behaviour and increase the climate resilience of MSMEs, drawing on examples from developed and developing countries. 'Climate insurance' is a catch-all term with different meanings in different contexts. For the purposes of this paper, a broad definition is used, encompassing all risk-transfer mechanisms that may be relevant to MSMEs potentially affected by adverse climate conditions. We conclude with reflections on how to harness the adaptation potential of insurance for MSMEs.

2. Climate risks and MSMEs

Although it is generally understood that the exposure of MSMEs to climate risks is rising (Surminski et al., 2016), it is difficult to generalize these risks. An MSME's size, sectoral focus and location, as well as the relevant policy and regulatory frameworks, all play a role in determining its exposure and vulnerability to climate change (Surminski et al., 2016). This variety of factors makes it almost impossible to group together the vast range of different enterprises under the MSME category: arguably, for instance, some medium-sized companies have much more in common with larger corporates than with micro-businesses. Climate change will also affect different business functions in unique ways. For example, some MSMEs may not rely on specific locations or premises, so climate change impacts on customer access may not be significant. On the other hand, disruptions to supply chains may have a significant impact. As such, any effort to analyse MSMEs as a group is bound to be somewhat artificial and to suffer from overlapping boundaries. This should be kept in mind when attempting to draw conclusions from current evidence.

Responding to climate change requires MSMEs to adapt to '…complex, non-linear and potentially irreversible environmental changes with uncertain impacts' (Linnenluecke & Griffiths, 2010; Winn, Kirchgeorg, Griffiths, Linnenluecke, & Günther, 2011; Linnenluecke, Griffiths, & Winn, 2012). New approaches may be needed to deal with the discontinuous changes that constitute climate change, particularly with regard to factoring in future uncertainties (Winn, Kirchgeorg, Griffiths, Linnenluecke, & Günther, 2011; Sur, 2012). However, MSMEs often lack the adaptive capacity to do this (e.g. Surminski et al., 2016; Crick et al., 2016). This low adaptive capacity arises through the small scale of their human and financial resources (Ingirige & Wedawatta, 2016). Adaptive capacity may also be limited by a lack of accessible and useable information on the nature of the climate risks faced by MSMEs (Downing, 2012; Murray & Marmorek, 2004), the costs and benefits of different resilience measures and how these may change over time.

As a result, MSMEs often fail to prepare for climate risks, a pattern that has been observed across different countries and contexts (Tierney & Dahlhamer, 1996; Webb, Tierney, & Dahlhamer, 2000; Alesch, Holly, Mittler, & Nagy, 2001; Ingirige, Jones, & Proverbs, 2008; Bannock, 2015). MSME planning horizon is often comparatively short, and thus might not recognize the value of being prepared for future

Table 1. MSME Snapshot

Adaptation Dynamic	Overall Assessment	Examples from Developed Countries	Examples from Developing Countries
Climate Risk Exposure	Exposure is rising for many MSMEs, depending on location and sector (Surminski et al., 2016). Low capacity to respond (Ingirige & Wedawatta, 2016).	For MSMEs in Europe flooding is biggest climate risk – direct and indirectly (Surminski et al., 2016; IFPCG, 2016). MSMES in the United States and Australia face broader array of risks, including flood and drought (Risky Business Project, 2014; Kuruppu, Murta, Mukheibir, Chong, & Brennan, 2013).	MSMEs more vulnerable due to resource constraints and low resilience (Ballesteros & Domingo, 2015). Large percentage operate in the informal sector, restricting access to adaptation mechanisms (Crick et al., 2016).
Potential Business Opportunities for MSMEs	Potential for development of new products and services that tackle climate change (Franco & Hanna Collado, 2016).	MSME in Netherlands proposing creation of a pop-up dam (Enterprise Europe Network, 2016). Some MSMEs see role in building community resilience building (FSB, 2015).	Indian SMEs creating new agricultural systems/ building materials (Franco & Hanna Collado, 2016).
Adaptation Responses by MSMEs	MSMEs have unique adaptation needs (Ingirige & Russell, 2015). Relatively little evidence on adaptation options and action taken (ASC, 2015).	Adoption of business continuity plans tends to be low (Surminski et al., 2016; American Sustainable Business Council and Small Business Majority, 2013). Take-up rates for adaptation measures generally poor across MSMEs (Ingirige & Wedawatta, 2016). MSMEs tend to rely on 'coping' strategies (UNDP, 2013).	Broad range of inhibiting factors, the greatest being lack of financing, (Malloch-Brown, 2016). Many adaptation programs require government or NGO support (Dougherty-Choux, Terpstra, Kurukulasuriya, & Kammila, 2015). Risk perceptions vary across sectors/locations – climate change may not be considered as a major risk (Mardanugraha, 2016).
Insurance and MSMEs	Limited data on use of insurance by MSMEs. Current discussions of reforming insurance or piloting new schemes tend not to consider MSMEs needs (Surminski, 2016).	MSMEs excluded from Flood Re in the UK (Surminski, 2016). Limited penetration of flood insurance for MSMEs in the United States (Riegel, 2016). Some MSMEs are content to rely on insurance in lieu of other adaptation measures (RICS Research, 2012). Insurance failing to incentivize the adoption of adaptation measures (DEFRA, 2016).	General low insurance penetration, but very limited understanding of situation for MSMEs outside of agriculture sector. Myriad of challenges faced by different insurance schemes (Schaefer and Waters, 2016). New programs such as InsuResilience being developed (von Gemmingen, 2016), but very few focused on MSMEs.

threats. This is compounded by a tendency to view climate change as a future risk that does not require immediate action (AXA and UNEP, 2015). MSME owners may also fear that focusing on adaptation may distract them from their core business, especially if there is uncertainty about the benefits these measures may deliver (Institute for Public Policy Research, 2016).

Increasing the adaptive capacity of MSMEs is therefore a significant challenge. AXA and UNEP (2015) suggest that financial incentives (e.g. tax relief, discounts in business rates, lower insurance premiums) may have an effect. Another study by FSB (2015) supports the point that MSMEs have a lack of accessible and useable information on risk and adaptation options. Asked which factors would encourage them to become more resilient to severe weather, MSMEs identified 'understanding the extent to which my business is at risk', 'understanding what plans I can make to help my business adapt' and 'knowing what specific products are available to help increase my resilience' as their top three (FSB, 2015). MSMEs could also be more active in local or city planning efforts on resilience, in sharing good practices with their peers and in interacting more with the government or wider society on climate change (AXA and UNEP, 2015). Adaptive capacity is also supported by strong organization structures and leadership; a stable, supportive and transparent policy environment; flexible planning and processes; and previous experience with climate change impacts, although this can also weaken adaptive capacity (Frontier Economics, Irbaris, & Ecofys, 2013).

In developing countries a large percentage of MSMEs operate in the informal sector (e.g. up to 90% in Kenya), restricting their access to finance, new market opportunities and public-sector services, which can play a part in their resilience to climate risks (Crick et al., 2016). They also tend to be more resource-constrained than MSMEs in developed countries (Ballesteros & Domingo, 2015), limiting their ability to respond to climate risks (e.g. MEFIN Network and GI RFPI Asia, 2016).

Importantly, climate change can also provide growth opportunities for MSMEs. Evidence from the UK suggests that a large percentage of MSMEs believe they can contribute to tackling climate change through their products and services (FSB, 2015). For example, Franco and Hanna Collado (2016) showcase Indian MSMEs involved in the development of climate-resilient building materials. Furthermore, reports from developing countries suggest that MSMEs may be in a better position to pursue such innovations than larger businesses due to their inherent flexibility, allowing them to refocus or relocate much more quickly provided they have the financial means to do so (GIZ, 2012).

Table 1 provides a broader snapshot of how MSMEs can be affected by climate change and the different dynamics that have been established in the literature. The table also shows come examples from developed and developing countries including the use of insurance by MSMEs, which is discussed in more detail below.

3. The use of insurance by MSMEs

Some of the business risks faced by MSMEs and other companies can be covered by insurance. For example, MSMEs may take out liability insurance to protect against third-party injury on their premises, health insurance to protect against employee illness, or business property insurance to protect against damage to their premises (Terungwa, 2012). MSMEs may also take out business interruption insurance to protect against any periods when they are unable to trade, for example, due to natural hazards or plant and equipment breaking down (Vero, 2016). However, gaps are emerging between what MSME owners perceive as major risks and those risks that are insurable (e.g. economic downturns) (Vero, 2016). In addition, there are concerns that insurance products are not being tailored to the unique needs of MSMEs; for example, because the MSME model mixes individual and business risks (Chatterjee & Wehrhahn, 2017).

To cover their business risks, medium to large-sized businesses tend to buy different insurance products and often engage a dedicated risk management team and an insurance manager, who negotiates their insurance rates, usually via a broker. This process includes reflecting on a range of risks such as fire and theft, but it can also include climate risks if they are deemed important enough and if cover is offered by insurers, who may choose to withhold insurance products in the face of rising risks due to, for example, higher claims ratios and low uptake (UNEP, 2016). These risks are often recorded in a risk register, enabling the company to develop a risk management strategy in response. For these businesses, insurance is likely to be one tool for resilience purposes, alongside risk retention, self-insurance or improved risk reduction efforts.

The situation is different with regard to MSMEs, particularly micro-sized companies, who often lack a formal process for managing risk and can usually not afford to employ risk experts (Chatterjee & Wehrhahn, 2017). Instead, the risk management and insurance buying approach of MSMEs is akin to that of residential or individual customers, who often lack risk management skills and, if they buy insurance, tend to take out standardized insurance products rather than tailor-made coverage, often via so-called aggregator-websites, without any face-to-face interaction between insurer and client. MSMEs may have to take out certain mandatory types of insurance protection, depending on the regulations of the country that they operate in, for example for liability risk, or they may be required to take out insurance under loan agreements or as part of a business contract. Surveys suggest that MSMEs generally have a relatively low understanding of insurance products (Chatterjee & Wehrhahn, 2017) and take up of policies that cover climate risks or the indirect risks associated with climate risks remains very low (UNEP, 2016). Consequential losses, for example, through lack of access to a shop or a supplier failure, are indirect risks that can have significant impacts on the operations of any business, regardless of its own physical location. Assessing such risks is difficult and requires a systematic risk assessment across all business areas, which for most MSMEs is very challenging and time-consuming.

Establishing insurance usage rates by MSMEs is not an exact science. In established markets, we see a variety of penetration rates across countries and insurance types. This is at least partly due to different states facing different risks, differing levels of awareness, different risk perceptions, the relative sophistication of insurance markets, historical developments and government intervention policies (Maccaferri, Cariboni, & Campolongo, 2012). In the UK, the majority of MSMEs (95%) possess some form of commercial coverage of their premises for a variety of reasons, including the legal requirement to do so (Ipsos MORI, 2015). However, it is unclear to what extent the insurance cover that MSMEs buy is sufficient (Crichton, 2006). For example, up to 66% of MSMEs in the United States do not have business interruption insurance (Sergakis, 2016). Similarly, statistics from Australia suggest that up to 80% of MSMEs concerned with being unable to trade claim not to have business interruption insurance (Vero, 2016). The situation is less transparent in countries such as Ireland, where there have been calls for greater information to be collected on MSME take-up rates to establish the extent of underinsurance or lack of insurance (Woods, 2016; Surminski, 2017).

Penetrations rates are generally lower in developing countries (e.g. Mechler, Linnerooth-Bayer, & Pepiatt, 2006, Ballesteros & Domingo, 2015), where insurance remains a relatively new and untested instrument. Recent efforts to expand the use of insurance tend to focus on observed barriers and how best to overcome them (e.g. Mechler et al., 2006; Steinmann, 2012; Glaesener-Nasr, Graham, Bianchessi, Suarez Bordon, & Fulco, 2017). Very few of these studies focus on MSMEs, but many of their general observations also apply to MSMEs. For example, Gurenko and Dumitru (2009) have pointed out a range of factors, such as low incomes, a lack of risk awareness and distrust in the ability of insurers that have a negative effect on insurance demand.

Specifically for MSMEs Lee observed questions of affordability, risk awareness and understanding in relation to the provision of flood insurance in the Pacific, despite the fact that insurers have expressed an interest in improving their MSME coverage (Lee, 2016). Cole, Stein, and Tobacman (2014) note that demand is also shaped by the experiences of local communities: where payouts have been made in the community, the likelihood of insurance uptake by others increases significantly. Where payouts are poor in the first few seasons, trust is eroded (Qureshi & Reinhard, 2015), but this creates a difficult situation for insurers too because higher payouts are a major disincentive for providing insurance in the first place.

In the wake of the micro-finance and micro-insurance boom, several new schemes were set up to improve access to finance for MSMEs, including micro-insurance products available for MSMEs, offering protection against theft or fire loss or damage to commercial premises, stocks in trade, plant and machinery, furniture, fixtures and fittings, alongside liability insurance (UNEP, 2016).

4. Insuring MSMEs against climate risks: recent experiences from developed and developing countries

Insurance is increasingly being viewed as a more effective way of addressing the costs of climate risks than relying on post-disaster payments (see, for example, Hallegatte, 2014; Brainard, 2008). This has led to the development of 'climate risk insurance' products designed to cover climate-related risks, particularly natural hazards. In developing countries, climate risk insurance often comes in two forms: 'weather-index microinsurance', where payouts are made to individuals or groups (i.e. the 'micro' and 'meso' levels) based on the performance of particular weather indexes (e.g. the amount of rainfall); and 'sovereign risk pooling', where national governments take out insurance to protect against particular extreme weather events (i.e. the 'macro' level). However, understanding the role that climate risk insurance can play in supporting MSMEs remains limited, even in countries with a well-established insurance tradition.

The increasing risks of climate change can also impact negatively on the business model of the insurance industry itself, which may choose to withhold insurance products in the face of increasing risks due to, for example, higher claims ratios and low uptake (UNEP, 2016). Currently, the industry's best defence against this is the one-year contract relationship with clients, which does not require an assessment of long-term risk and offers flexibility in amending and adjusting price coverage on an annual basis. However, this is only a short-term defence against the threat of increasing risk. If significant efforts are not taken to reduce risk by increasing resilience, costs will continue to rise, and insurers may stop offering climate change-related insurance products; indeed, adaptation could feasibly become a prerequisite to receiving insurance in the first place (Golnaraghi, Surminski, & Schanz, 2016). The recent efforts in both developed and developing countries to reform or extend the use of

insurance in response to climate risks tend to be focused on either individuals such as farmers or homeowners, or on governments through sovereign risk insurance schemes.

4.1 Experiences from developed countries

In developed insurance markets, governments often accept the need to intervene to secure the affordability and availability of insurance for individual homeowners, but there are few dedicated schemes for MSMEs.

Overall MSMEs tend not to be at the forefront of government efforts to reform insurance (Surminski, 2016), and there is often very limited understanding (and little hard evidence) of how they are covered, affected or whether MSMEs are adopting resilience measures, as is the case in the United States per Department of Homeland Security (2016). This is also evident in the current discussions over flood insurance in Ireland, where a lack of access to insurance has become a concern for local businesses in the wake of recent flooding events; indeed, the evidence suggests that MSMEs face progressively increasing insurance rates in general (Leech, 2015). However, data about uptake, cover levels and price remain scarce and anecdotal.

In the UK, the new reinsurance pool Flood Re, which came into operation in April 2016, does not cover MSMEs. Under Flood Re, insurers can reinsure high flood risk policies for a reduced price, allowing them to limit the premiums charged to policyholders (Surminski & Eldridge, 2015). However, MSMEs are excluded from Flood Re on the basis that the difficulties they face in accessing flood insurance tend to be localized and do not justify a countrywide solution (Surminski, 2016). This was a major criticism of the model when it was first proposed, made by the British Property Foundation (BPF, 2013) and the Federation of Small Businesses (Clarke, 2017). Since then, the British Insurance Brokers' Association has confirmed that it is working on developing a scheme to make flood insurance more affordable for MSMEs (Barton, 2016). The government has also announced that it may consider a Flood Re-style mechanism for MSMEs if access to insurance for MSMEs becomes more difficult in the future (Axling, 2016). This suggests that a solution for MSMEs may be forthcoming in the future, though no details of any proposed scheme have been released to date. For completeness, the notion that MSMEs require their own solution is relevant to developed and developing countries, as with the use of microinsurance in developing countries, which is briefly discussed below.

Insurance penetration rates for climate –related risks faced by MSMES are highest when part of a wider package of insurance, which MSMEs may be required to purchase to secure loans, mortgages or business contracts.

Business interruption insurance is often included in business insurance packages, which combine a number of different policies under one premium, or it can also be offered as an optional extra to buildings and contents insurance policies (ABI, 2014). However, a 2011 study by AXA Insurance of MSMEs in nine developed countries and India found that only 39% of MSMEs claim to have business interruption cover to protect against lost income resulting from unforeseen events (AXA, 2011). This is despite the fact that climate risks can have ripple-on effects for MSMEs, for example, through supply chain disruption, as seen during the 2015 Chennai floods (Chandrasekaran & Arunachalam, 2015). Where MSMEs take out climate-related insurance, it is predominantly for property-related risks; for example, although MSMEs tend to be more mobile than other businesses, they are slow to return to their original premises after a flooding event, if they manage to do so at all (Surminski et al., 2016).

Recent concerns about the affordability and availability of insurance cover for MSMEs have spurred discussion about innovative mechanisms in developed markets, such as 'community insurance schemes', mutuals, or the application of index-based insurance.

One option to expand insurance cover for MSMEs is community insurance, based on 'a single policy, purchased by a local governmental or quasi-governmental body, which covers a group of designated properties' and could also include local businesses (Kousky & Shabman, 2015). Community insurance would address a number of the challenges faced by MSMEs. Perhaps most importantly, it recognizes the fact that MSMEs are deeply rooted in their local communities, with MSME owners often feeling the dual impact of natural hazards on both their private and business properties (RICS Research, 2012). This could allow MSMEs to take advantage of the economies of scale that exist at the community level, thus reducing their costs. Payouts may be capped, helping to mitigate the 'moral hazard' of insurance (Kousky & Shabman, 2015). This could also improve its

marketability: if community insurance were more expensive than the accumulation of individual policies within a given area, it would not be adopted (Kousky & Shabman, 2015).

Another option that could address concerns about the lack of affordability and availability for MSMEs are mutual schemes, where businesses form a club and insure each other. This has been done successfully for certain sectors, often in response to a lack of commercial insurance or price rises. An example is FM Global, which originated as a mutual insurance company owned by its members. Interestingly, these mutuals were based on strict risk-management rules, with members expecting each other to adapt to reduce losses as a result of climate risks. In recent discussions about flood insurance for MSMEs in the UK, such mutual solutions received some brief attention, but were then dismissed in favour of Flood Re. Index-based insurance products have so far seen little application in developed markets, but they may offer inexpensive and simple coverage to businesses as they avoid the costly establishment of the extent of losses and damage after an event. Discussions in this direction have only emerged recently.

There is little evidence on direct links between climate insurance and adaptive behaviour by MSMEs in developed markets.

In practice, there is limited evidence of the success of insurance in encouraging risk-reduction behaviour by households in developed markets (Thieken, Petrow, Kreibich, & Merz, 2006; Treby, Clark, & Priest, 2006; Crichton, 2008; Botzen, Aerts, & van den Bergh, 2009; Lamond, Proverbs, & Hammond, 2009; McAneney et al., 2013; Surminski & Eldridge, 2015). This highlights the fact that insurance is not a solution to be pursued in isolation, and it appears reasonable to expect a similar result for MSMEs in light of the low levels of adaptation they have engaged in (see section 2 above). This has led to criticism that insurance, at least in its current structure, can be detrimental to overall adaptation and disaster risk management as it creates disincentives for resilience (because of the possibility of moral hazard) and can lead to maladaptation (O'Hare, White, & Connelly, 2015). Indeed, recent discussions in several developed insurance markets show uncertainty among insurers regarding how to evaluate the benefits of risk reduction measures (DEFRA, 2016). This reinforces the fact that insurance only forms one part of disaster risk management and may not remain affordable or available unless risks are better managed. For example, an MSME affected by flooding in Braunton, Devon, reported that it was forced to give up insurance because of the hike in premiums it faced following the flooding (Ingirige & Russell, 2015). In the long-term, it is crucial that such MSMEs adopt resilience measures to reduce their risk in the first place.

4.2 Experiences from developing countries

Very few insurance schemes in developing countries directly target MSMEs.

Overall, the use of insurance to protect against climate and disaster risks in developing countries remains very low. The ClimateWise Compendium (ClimateWise, 2011) on disaster risk transfer, which provides a summary of such schemes, documents 123 existing initiatives in middle-income and lower-income countries that involve the transfer of financial risk associated with the occurrence of natural hazards such as flooding (Surminski & Oramas-Dorta, 2014). This dataset is currently being updated.

However, a number of recent initiatives are aimed at increasing the use of insurance in developing countries:

At the macro-level (sovereign risk, covering public budgets) there are a number of regional risk pools, such as the African Risk Capacity (ARC), the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI), and the Caribbean Catastrophe Risk Insurance Facility (CCRIF). Furthermore, the Extreme Climate Facility (XCF) will provide African countries with funding to implement predetermined adaptation plans if certain pre-determined climate data thresholds are exceeded. It works in conjunction with the ARC. However, these schemes are not generally targeted at MSMEs specifically, and there is a lack of information regarding how MSMEs are engaging with them. While there are several examples of the use of insurance to support agricultural MSMEs, but there often remains confusion about extent of the coverage and types. For example, a study of the impact of the 2010 floods in Pakistan showed that few MSMEs had insurance, but there appeared to be some confusion among MSMEs as to whether they were covered or not and against what type of risk (Asgary, Imtiaz Anjum, & Azimi, 2012). A more recent study of Indonesian MSMEs suggests that only 4% of them utilize natural catastrophe insurance as their top risk-financing mechanism (Mardanugraha, 2016). Index-linked insurance

is widely perceived as a particularly effective means of providing insurance in developing countries because it tends to have lower assessment costs and reduces the moral hazard associated with traditional insurance contracts (Schaefer & Waters, 2016).

At the meso level insurance products are targeted at 'risk aggregators' such as professional associations, NGOs, mutuals, community assoications and other cooperatives (Schaefer & Waters, 2016). These products may therefore benefit those MSMEs that are members of such cooperatives. For example, PlaNet Guarantee provides drought index insurance to farming cooperatives in Benin, Burkina Faso, Mali and Senegal (Schaefer & Waters, 2016). Similarly, the Index Based Flood Insurance Program (IBFIP) provides meso-level insurance for catastrophic flooding in Bangladesh (Schaefer & Waters, 2016). However, such schemes appear still limited in number.

At the micro-level, insurance products may be targeted at the owners of MSMEs directly as policy-holders. For example, a large number of products are aimed at farmers in developing countries, including the Modified National Agricultural Insurance Scheme (MNAIS) in India, the SANASA agricultural insurance scheme in Sri Lanka and the Micro-Haiti scheme, which is targeted at women-owned enterprises (Schaefer & Waters, 2016).

Micro-credit and micro-insurance products are often linked.

One example for the combination of micro-credit and micro-insurance provision is Kore W in Haiti, which is aimed at small entrepreneurs who take out loans from the micro-finance provider Fonkoze. Coverage is mandatory, with a premium of 3% of the loan. In the event of a natural disaster, businesses are eligible for a US$125 indemnity payout, the reimbursement of the client's existing loan balance with Fonkoze and the right to take out a new loan when ready to recapitalize. This is possible because Fonkoze is, in turn, covered by MiCRO, a strategic collaboration between a number of stakeholders including Fonkoze, Mercy Corps, Swiss Re, Caribbean Risk Managers Limited, Guy Carpenter and Company, LLC, Alternative Insurance Company (AIC), SFRi, the UK Department for International Development (DFID) and the Swiss Agency for Development and Cooperation (SDC). While supporting financial resilience, it is somewhat unclear how these products address the real needs of MSMEs in the wake of a disaster, as they often seem to 'fail to consider that especially micro and small enterprises are part of the agricultural value chains with varied protection needs' (MEFIN Network and GI RFPI Asia, 2016).

MSMEs may play a role in distributing climate risk insurance products through their shops.

Local retailers, small shops and kiosks can play a role in distributing insurance to their clients by taking on the role of an intermediary. Examples are the extensive networks of so-called 'banking correspondents' that have emerged in countries such as Brazil and India. Small shops, hairdressers or other local service providers take on the distribution of micro-finance and micro-insurance products on behalf of banks or insurers. While this provides a new business opportunity for MSMEs, it is unclear to what extent this may also lead to greater use of insurance products by the same MSMEs to cover their own risks.

The cost-effectiveness of insurance, particularly in developing countries, remains somewhat unclear, and many MSMEs appear to be either unable or unwilling to pay insurance premiums.

In the face of increasing risks, there are growing calls for financial support to enable those who are most vulnerable to take out insurance. However, while affordability is often cited as a key barrier to disaster risk insurance, a broader review of the literature conducted by Vivid Economics et al. (2016) identified a range of other potential barriers to increasing insurance take-up. Understanding these barriers is important when designing new schemes, reforming existing ones or considering how to boost take-up by MSMEs. Current discussions about premium subsidies, while not yet specifically framed in the context of MSMEs, are likely to intensify when seeking further expansion of insurance across developing countries. As Vivid Economics et al. (2016) show, providing premium subsidies in the presence of certain barriers to insurance may be counterproductive, while there are some barriers which premium subsidies can help alleviate substantially and hence help increase penetration rates. Most clearly, on the demand side, premium subsidies can help in instances where the insurance buyer is particularly poor (Vivid Economics et al., 2016).

There is little evidence on direct links between climate insurance and adaptive behaviour by MSMEs in developing markets.

Generally speaking, few climate risk insurance schemes in developing countries draw a direct link with risk reduction. To the extent they do, the links with MSMEs or the specific adaptive behaviour of MSMEs can be unclear. This has been demonstrated by Surminski and Oramas-Dorta (2014) in the context of flood insurance, with two-thirds of the schemes they identified having no link to risk reduction. A similar conclusion was reached by Schaefer and Waters (2016), who identified only two climate-risk insurance schemes in developing countries where there is evidence that a positive impact has been made on risk reduction. These schemes are MNAIS in India, which allows farmers in a given area to access premium discounts if they adopt sustainable farming and water conservation practices, and the R4 Initiative, which allows farmer to work for their insurance cover in, for example, improved irrigation and soil management projects. Hess and Hazell (2016) also note the R4 Initiative's unique structure in this respect and suggest that subsidies or early recovery vouchers could be used to plug the gap in risk reduction. Denno Cissé and Ikegami (2016) suggest that holding index-based livestock insurance can improve resilience in terms of livestock holdings during periods of drought, but the link to adaptive behaviour is unclear. In the absence of direct links to risk reduction, there remains the risk that the moral hazard of insurance may lead to maladaptation (Tanner et al., 2015).

5. Conclusion: insurance as an adaptation tool for MSMEs?

MSMEs are crucial to the global economy. They form the majority of businesses in most countries and are heavily integrated into local communities. As a result, it is important to consider the impacts of climate change and options for MSMEs to adapt to these changes, particularly in developing countries, where its effects will be most acutely felt (Warner et al., 2010). The limited but growing evidence of the climate risk exposure and adaptation efforts of MSMEs suggests a generally low level of adaptive capacity and limited use of financial support mechanisms such as insurance. For MSMEs who aspire to grow and who often display immense entrepreneurial skills, particularly in the face of adversity, insurance can help to plan ahead and take positive business risks, while transferring the disaster risks. As such it can support climate resilience. But this is unlikely to be a long-term solution if broader efforts to reduce overall climate risk are not made by MSMES, but also other stakeholders, including infrastructure investors. Ultimately insurance is not a panacea, and, in the absence of significant risk reduction work, insurance will remain a very short-term measure that MSMEs should not rely on too much.

Climate risk insurance has the potential to support climate change adaptation if it is designed and implemented with risk reduction in mind. However, most climate risk insurance schemes are not structured with this in mind but instead focus on the short-term transfer of risk rather than building resilience in the longer term. For example, the new flood reinsurance scheme in the United Kingdom, Flood Re, seeks to keep insurance prices low by providing insurers with affordable reinsurance. However, this approach is only a 'stop-gap' solution to shielding insurance customers from the costs of increasing risk. Ultimately risk transfer does not equal risk reduction, and insurance will only be affordable for MSMEs in the long-term if the 'adaptation gap' is closed and risks are better managed. To harness the adaptation potential of climate risk insurance, a number of steps can be taken in the immediate future to improve underlying knowledge of adaptation:

First of all, better monitoring and evaluation mechanisms for existing schemes are needed in both developing and developed countries. At the moment, there is a lack of rigorously designed studies examining how insurance influences resilience and measures of well-being, such as food security and transitions from poverty (Schaefer & Waters, 2016; Hess & Hazell, 2016). Furthermore, there is significant uncertainty concerning which resilience indicators to use in the monitoring and evaluation of insurance initiatives (Schaefer & Waters, 2016); more research in this regard would allow ongoing monitoring and evaluation of how insurance promotes resilience. In developed markets, there is often not enough assessment of the needs of MSMEs and their uptake of insurance, as seen in the UK and Ireland (Surminski, 2017; Surminski, 2016). However, there are challenges in achieving this; for example, such data are typically not a public good and are not collected by MSMEs themselves.

Secondly, greater emphasis should be placed on the capacity-building and risk education that can come from using insurance. Risk transfer can provide incentives for MSMEs to set up business continuity plans, which could,

in fact, become a condition for cover, while insurers provide support and advice as part of the risk transfer transaction. Insurers could play a more prominent role in providing information on risk reduction options and the benefits of adopting them; currently, they are poor communicators in this regard (DEFRA, 2016). This points to the potential for insurance to assist MSMEs in transforming their vulnerability and exposure to hazard, as promoted by the G7 InsuResilience initiative, which aims to improve the climate resilience of the most poor and vulnerable through insurance instruments. A recent report by the Munich Climate Risk Insurance Initiative (2016) identifies a number of 'pro-poor' principles that InsuResilience should seek to satisfy, including but not limited to affordability, participation and sustainability (Schaefer & Waters, 2016). This can also guide those involved in designing or implementing insurance for MSMEs.

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The role of multilateral climate funds in unlocking climate finance and action in developing country MSMEs

Abstract

Multilateral climate funds make it possible to pilot and test financial products and instruments for use in overcoming the actual and perceived costs and risks associated with lending to micro small medium enterprises (MSME). Analysis of nine climate funds shows that climate action in MSMEs is supported through small but increasing volumes of funding. The most sustained engagement has been by the Global Environment Facility (GEF), while the operationalisation of the Green Climate Fund has increased these volumes dramatically. Other funds have become involved to a lesser degree. However, support is concentrated on renewable energy and energy efficiency projects, not adaptation. The recent inclusion of MSME actions in the Adaptation Fund portfolio and GEF commitments to increase adaptation action in the private sector are promising shifts in the right direction. But more work is needed before multilateral climate funds can demonstrate and unlock the adaptation opportunities that MSMEs present. This is the case not only in increasing the role of less-concessional finance for adaptation, which not all funds are able to offer, but also to ensure that the appropriate entities are accredited to those funds that can best support MSMEs in undertaking adaptation actions.

1. The role of multilateral climate funds in supporting climate action in micro, small and medium enterprises

While we continue to curb greenhouse-gas emissions, we remain locked in to a degree of climate change. The impact of these historical emissions, and of those we emit as we shift to lower-emission development pathways, makes adaptation to climate change unavoidable. A number of adaptation measures will be undertaken by the state, providing local public goods. However, the whole range of private-sector actors will also have to adapt by mitigating or profiting from climate change impacts (Druce, Moslener, Gruening, Pauw, & Connell, 2016). The involvement of private-sector actors is critical if the scale of action necessary to adapt to the changing climate is to be reached. A necessary complement to public climate finance, these private-sector actors can also contribute solutions and expertise in climate action.

Micro, small and medium enterprises (MSMEs),[1] both formal and informal, are key private-sector actors in respect of the response to climate change. While technical definitions of MSMEs, such as number of employees, assets and sales, will vary between countries and institutions (SME Finance Forum, 2014), they remain important as a group. Estimates show that they employ over 70% of the population in low-income countries and 95% in middle-income countries. Often embedded in the local context under which action must be taken, MSMEs have a 'social license' to operate and can disseminate vital climate information (Terpstra & Ofstedahl, 2013). Climate change adaptation efforts made by MSMEs to reduce or transfer the physical risks to their businesses could also protect economic growth and development gains, given that they account for between 60-75% of GDP in low- and middle-income countries (OECD, 2004). MSMEs can also capitalize on the new business that climate change creates, providing new affordable goods and services based on their knowledge of local needs and responses (Druce et al., 2016).

Many MSMEs have limited access to climate finance, restricting their ability to take advantage of market opportunities or to protect against climate risks. This is true even where there is the prospect of long-run returns. This makes MSMEs increasingly vulnerable to climate change (Druce et al., 2016). Dalberg (2015) suggests that the barriers to MSMEs accessing climate finance include weak policies and limited knowledge and awareness of opportunities, while weak financial infrastructure and political instability can also limit the attractiveness of investing in MSMEs more broadly.

Multilateral climate funds have the potential to address and reduce the barriers and challenges to climate action in MSMEs. Such funds have key roles in demonstrating good practice and are able to take a degree of risk that other sources of finance cannot (Nakhooda et al., 2014). Thus, while multilateral climate funds represent a fraction of global flows of public climate finance,[2] they offer both a source of finance for climate action and a way of piloting and testing financial products and instruments that can overcome the actual and perceived high costs and high risks associated with lending to MSMEs.

Comprehensive understanding of how the major multilateral climate funds contribute to MSMEs is currently lacking. This largely results from the fact that there are often no explicit markers to indicate which projects are targeting MSMEs and to what extent, although some consideration has been given to how the multilateral funds engage with the private sector more broadly (Nakhooda et al., 2014; Whitely, Chiofalo, & Barnard, 2014). This paper adds to this by taking an initial look at nine dedicated climate funds, five of which operate as financial mechanisms under the United Nations Framework Convention on Climate Change (UNFCCC), to determine their explicit contributions of climate finance to MSME actions related to both adaptation and mitigation. This paper then seeks to identify how multilateral climate funds could accelerate adaptation actions by MSMEs specifically. With significant numbers of MSMEs in the developing world vulnerable to a changing climate, and against the backdrop of commitments to double climate finance for adaptation by 2020, this paper suggests that multilateral climate funds have a role in accelerating and unlocking the potential contribution of MSMEs to climate change action, particularly for adaptation.

[1] This paper uses the term MSME broadly and does not set out a definition of its own in terms of size and investment. It accepts the term as used by various projects and institutions at face value without comparing definitions between them so as not to become involved in a debate around definitions. In those instances where SME is used, it refers directly to a project or objective of a particular institution whose definition of SME may not overlap with definitions of MSME.

[2] In 2014, the contribution of these funds was estimated at $2.2 billion annually or just 5% of total public climate finance flowing to developing countries (including bilateral and multilateral development bank finance (UNFCCC, 2016). In 2020, they are expected to deliver just 2% of international public climate finance flows (DFAT and BEIS, 2016).

Table 1. Dedicated multilateral climate change funds considered in this analysis.

indicates funds supporting mitigation indicates adaptation indicates both mitigation and adaptation activities.

Fund	Objectives and structure	Pledge	Projects approved	Projects approved (USD)
UNFCCC Funds				
Global Environment Facility* (1991)	The GEF aims to help developing countries and economies in transition to contribute to the overall objective of the United Nations Framework Convention on Climate Change (UNFCCC) to both mitigate and adapt to climate change, while enabling sustainable economic development. The GEF is intended to cover the incremental costs of a measure to address climate change relative to a business-as-usual base line	$20.65 billion	3690	$14.5 billion
Least Developed Countries Fund (2002)	The Least Developed Countries Fund (LDCF) was established to meet the adaptation needs of least developed countries (LDCs). Specifically, the LDCF has financed the preparation and implementation of National Adaptation Programs of Action (NAPAs) to identify priority adaptation actions for a country based on existing information.	$1,250.16 million	238	$981.24 million
Special Climate Change Fund (2002)	The Special Climate Change Fund (SCCF) was created in 2001 to address the specific needs of developing countries under the UNFCCC. It covers the incremental costs of interventions to address climate change relative to a development baseline. Adaptation to climate change is the top priority of the SCCF, although it can also support technology transfer and its associated capacity-building activities.	$367.31	73	$301.89
Adaptation Fund (2009)	The Adaptation Fund supports concrete adaptation projects and programs in developing country Parties to the Kyoto Protocol, in an effort to reduce the adverse effects of climate change facing communities, countries and sectors. The Fund is financed through both governments and private donors, and from a 2% share of the proceeds from Certified Emissions Reductions (CERs), issued under the Kyoto Protocol's Clean Development Mechanism (CDM).	$569.15 million	54	$348.91 million
Green Climate Fund (2015)	In the context of sustainable development, the Green Climate Fund aims to promote a paradigm shift towards low-emission and climate-resilient development pathways by providing support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change. It takes into account the needs of those developing countries that are particularly vulnerable to the adverse effects of climate change.	$10.3 billion	37	$1.2 billion
Non-UNFCCC Funds				
Clean Technology Fund (2008)	The Clean Technology Fund (CTF), one of two multi-donor trust funds within the Climate Investment Funds (CIFs), promotes scaled-up financing for the demonstration, deployment and transfer of low-carbon technologies with significant potential for long-term greenhouse gas emissions savings.	$5.5 billion	101	$5 billion
Pilot Program for Climate Resilience (2008)	The Pilot Program for Climate Resilience (PPCR) is a targeted program of the Strategic Climate Fund (SCF), one of two funds within the Climate Investment Funds (CIF) framework. The PPCR aims to pilot and demonstrate ways in which climate risk and resilience may be integrated into core development planning and implementation by providing incentives for scaled-up action and initiating transformational change.	$1.1 billion	65	$972.5 million
Forest Investment Program (2009)	The Forest Investment Program (FIP) is a targeted program of the Strategic Climate Fund (SCF) within the Climate Investment Funds (CIF). The FIP supports developing countries' efforts to reduce deforestation and forest degradation (REDD) and promotes sustainable forest management that leads to emission reductions and the protection of carbon reservoirs. It achieves this by providing scaled-up financing to developing countries for readiness reforms and public and private investments, identified through national REDD readiness or equivalent strategies.	$744 million	23	$335.27 million
Scaling Up Renewable Energy in Low-Income Countries Program (2009)	The Scaling-Up Renewable Energy Program in Low Income Countries (SREP) is a targeted program of the Strategic Climate Fund (SCF), one of two funds within the Climate Investment Funds (CIF) framework. The SREP was designed to demonstrate the economic, social and environmental viability of low-carbon development pathways in the energy sector in low-income countries. It aims to help low-income countries use new economic opportunities to increase energy access through renewable energy use.	$744.65 million	25	$236 million

*The GEF pledge, projects and approved amounts are taken from GEF (2016), as the CFU covers GEF Trust Funds 4, 5 and 6.
Source: Climate Funds Update, data correct as of October 2016 unless stated otherwise.

2. Support for action in MSMEs by multilateral climate funds

2.1. The extent to which MSMEs are embedded in multilateral climate fund processes

Multilateral climate funds have their own origins and histories, but they overlap with the objectives of supporting and accelerating climate action in developing countries (Nakhooda et al., 2014). The oldest multilateral fund, and first operational entity of the financial mechanism of the UNFCCC, is the Global Environment Facility (GEF), which has provided funding since 1992 working with a number of partner agencies. Three further financial mechanisms of the UNFCCC are hosted by the GEF Secretariat, namely the Least Developed Countries Fund (LDCF) from 2002, the Special Climate Change Fund (SCCF), also from 2002, and the Adaptation Fund (AF) from 2009. The UNFCCC's fifth and latest financial entity is the Green Climate Fund (GCF), operational since 2015. It is responsible to the Conference of the Parties, but is a legal entity in its own right (Schalatek, Nakhooda, & Watson, 2016). Outside the UNFCCC process, the Climate Investment Funds (CIFs) are the most influential of the multilateral climate funds. These are two World Bank-administered funds, namely the Clean Technology Fund (CTF) and the Strategic Climate Fund (SCF). The SCF itself comprises three programmes: the Pilot Program for Climate Resilience (PPCR), the Forest Investment Program (FIP) and the Scaling Up Renewable Energy in Low-Income Countries Program (SREP). These funds, their objectives, and their pledged and approved finance are outlined in Table 1.

Multilateral climate funds share the desire to mobilize private-sector actors and finance for climate change, though they have different modes of operations. For example, the Adaptation Fund, LDCF and SCCF do not have private-sector engagement as a primary emphasis, though there are instances of projects where private-sector actors have been targeted. Other funds have a much more targeted approach. Thus GEF's private-sector reach has been increasing (although not solely into the climate change focal area), while for the CIFs and GCF, mobilizing private finance is central to their governing documents (Amerasinghe, Thwaits, Larsen, & Ballesteros, 2017).

The **Global Environment Facility (GEF)** targets business and private-sector investment through a number of intervention models, including transforming policy and regulatory environments, deploying innovative financial instruments, convening multi-stakeholder alliances, strengthening institutional capacity and decision-making, and demonstrating innovative approaches (GEF Secretariat, 2015). There have been a number of GEF programmes supported by the private sector, and the fund has targeted MSME engagement from the outset. The first GEF programme to target SMEs was approved in 1995, which, including its replenishment in 1997, provided a total of $20.8 million as a concessional loan in order to address the barriers to environmental SME finance (Table 2). The GEF has since financed several similarly large multi-country programmes that have targeted the MSME sector.[3] The experience of the GEF in supporting MSMEs and its increased desire to engage private-sector actors in the climate-focal area in general could lend itself well to scaling up MSME actions for adaptation specifically. With good co-financing ratios, its actions could also catalyse greater flows to MSMEs. However, with co-financing also predominantly from the public sector (Amerasinghe et al., 2017), such actions may require a shift in the primary recipient of GEF funds (often government) or a more specific focus on what public finance institutions are able to achieve to this end.

Adaptation is addressed centrally by two funds for which the GEF is the Secretariat, namely the **Special Climate Change Fund (SCCF)** and the **Least Developed Country Fund (LDCF)**. Neither fund has a specific private-sector modality 'due to the current dominant role of public institutions in adaptation finance' (GEF Secretariat, 2012). Nonetheless, both funds acknowledge the benefits and opportunities of greater private-sector engagement and aim to identify additional approaches and mechanisms for engaging the private sector through 'systematic dialogue with private sector stakeholders' (GEF Secretariat, 2012). Currently, however, no SCCF and only one LDCF project explicitly is targeting MSMEs. These are small funds, operating through grant instruments. Contributions to increasing adaptation by MSMEs might therefore focus instead on the barriers to climate finance that focus on capacity, information or a public policy enabling environment, rather than on providing more direct support through innovative financial instruments, for example. This focus could complement GEF engagement, as well as clarify the role of the GEF, which provides grant

[3] Further GEF programmes supporting MSMEs have included the Environmental Business Finance Program (EBFP), which received a $20 million grant, the Central American Markets for Biodiversity (CAMBio), for which a $10.2 million concessional loan was provided to facilitate the mainstreaming of biodiversity and sustainable use within MSME development and financing, and the GEF UNIDO Cleantech Programme, a competition and incubation pilot for which $8.7 million was provided.

Table 2. The barriers to mobilizing environmental SME finance addressed by the GEF Small and Medium Scale Enterprise Program (International Finance Corporation, 2002)

Barriers	IFC Program Response
Lack of access to finance: experience and capacity deficit in host-country financial sector	Provision of direct loans and risk-sharing financing to induce/support intermediary lending. Technical assistance (TA) to intermediaries to develop understanding of market opportunities; facilitate introduction to SMEs; technical support for developing credit analysis skills and financial products
High perceived risk for SME borrowers and environmental projects by intermediaries	TA support to develop credit analysis skills for appraising environmental project risk; provision of credit enhancement to mitigate actual risk to intermediaries
Lack of collateral value associated with environmental projects and equipment	Provision of risk-sharing to mitigate intermediaries' risk; TA support to intermediaries to develop project finance capabilities and value the positive security features of environmental projects: cost savings that improves free cash-flow of end-user, and essential use nature of environmental equipment
Excessive collateral requirements imposed by intermediaries	Provision of credit enhancement to mitigate actual risk to intermediaries
Extraordinarily risk-averse financial markets resulting from historical experience of poor credit procedures	Provision of partial guarantee to mitigate actual risk to intermediaries. Selection of priority markets, e.g., SMEs, where project finance techniques can be applied, the viability of borrowers demonstrated, and competition between financial institutions can result in new lending
Lack of well-prepared projects	Selection of markets where the fundamental economics of environmental projects are attractive; TA support to SMEs to assist in project structuring and presentation

and concessional financing to cover the incremental costs of international environmental conventions and agreements in five broad areas, including climate change mitigation), whereas the LDCF and SCCF, provide grants for adaptation actions alone. An opportunity to do this will arise when the GEF revises its adaptation strategy for its 7th replenishment to include enhanced private-sector engagement as a key mechanism for innovation.

The **Adaptation Fund (AF)** does not count private-sector engagement and participation as one of its objectives, and applications to it do not need to demonstrate that co-financing or private-sector action are being mobilized. However, Trujillo & Nakhooda (2013: 7) found that in practice many programs have engaged private-sector companies both as implementation partners and as key targets and stakeholders in program implementation. MSMEs have not been targeted directly to date, but two projects currently at the proposal stage (as of February 2017) will do so. Well known for pioneering direct access to climate finance, this could be an important fund for accelerating MSME action. The Small Grants Facility, for example, could help build up the capacity of local institutions, but this could depend on accreditation where it works through new, relevant local entities, and the small project amounts approved by the Adaptation Fund (in light of the country cap) might be insufficient to catalyse a shift in MSME engagement in adaptation beyond a specific local context.

The **Green Climate Fund** targets private-sector engagement through its Private Sector Facility (PSF). The PSF's mandate is 'to fully engage private sector investors, developers, entrepreneurs, corporations, and small and medium sized enterprises (SMEs) in climate-sensitive and resilient projects throughout the developing world' (GCF, 2017). There are a number of modalities under the PSF that aim to reach the private sector in targeted ways, such as modalities for mobilizing funds at scale from institutional investors through various financial products and structures; modalities for mobilizing funds at scale from institutional investors and local and international private actors by leveraging participants in projects or programmes financed by the fund; and a modality for promoting the participation of local private-sector actors entitled *Private Sector Facility: Working with Local Private Entities, including Small and Medium-Sized Enterprises* (GCF, 2015).

Through the last-mentioned modality of the GCF, a pilot programme to support MSMEs was agreed at the GCF's 10th Board Meeting in 2015. This $200 million programme,

which has a $65 million cap for each region, aims to provide financing for MSMEs across a range of climate-relevant adaptation and mitigation activities, and at any phase of growth or stage in the supply chain (GCF, 2016a). Among the initiatives suggested in Board documentation are incubators and accelerators that provide technical and strategic support, a financing model to build a pipeline of bankable projects, and innovation funds and prizes (GCF 2016b). The GCF could promote adaptation action in MSMEs by means of a wider range of financial instruments than other funds, though it has yet to confirm its appetite for risk. It is also able to programme much larger amounts of resources than some of the smaller multilateral funds. In its early stages of operation, however, and with a number of decisions still to be taken, it may take some time to elaborate the approach for adaptation in MSMEs.

Outside the UNFCCC, the **Climate Investment Funds** (CIFs) are key dedicated climate funds, consisting of the **Clean Tech Fund** (CTF) and three **Strategic Climate Funds**: the **Pilot Program for Climate and Resilience** (PPCR), the **Scaling-Up Renewable Energy Program** (SREP) and the **Forest Investment Program** (FIP). The **CTF** targets private-sector engagement through its Dedicated Private Sector Programs. Launched in 2013, it uses a programmatic approach to finance private-sector mitigation projects that can deliver at scale (in terms of development results and impact, private-sector leverage and investment from CTF financing) and speed (faster deployment of CTF resources, more efficient processing procedures). The Dedicated Private Sector Programs have allocated finance to six thematic areas: geothermal power, mini-grids, mezzanine finance, energy efficiency, solar PV and early-stage renewable energy programs (CTF, 2017). While MSMEs may receive funding as part of projects through this programme, the CTF does not have a mechanism specifically targeting MSMEs. The three **Strategic Climate Funds** target the private sector through Private Sector Set-Asides, which target innovative programs and projects that engage the private sector in areas that advance the funds' objectives through the competitive allocation of concessional funding (CIF, 2017). While none of the three funds have mechanisms or provisions that directly target MSMEs, some of the programs and projects approved as part of a set-aside are likely to reach MSMEs or have MSMEs as their main target group.

The CIFs have broadened the use of financial instruments within the climate funds, particularly through the use of concessional loans. This can encourage higher risk investments without the higher interest rates that may address some of the barriers to MSMEs accessing climate finance. The CIFs, however, operate in a small number of countries and first work with countries to develop investment plans. It is also only the PPCR that focuses on adaptation. Thus, the private-sector activities funded through the PPCR are largely dependent on the development planning undertaken by the funded national governments, potentially making it difficult to design overarching objectives to target MSMEs.

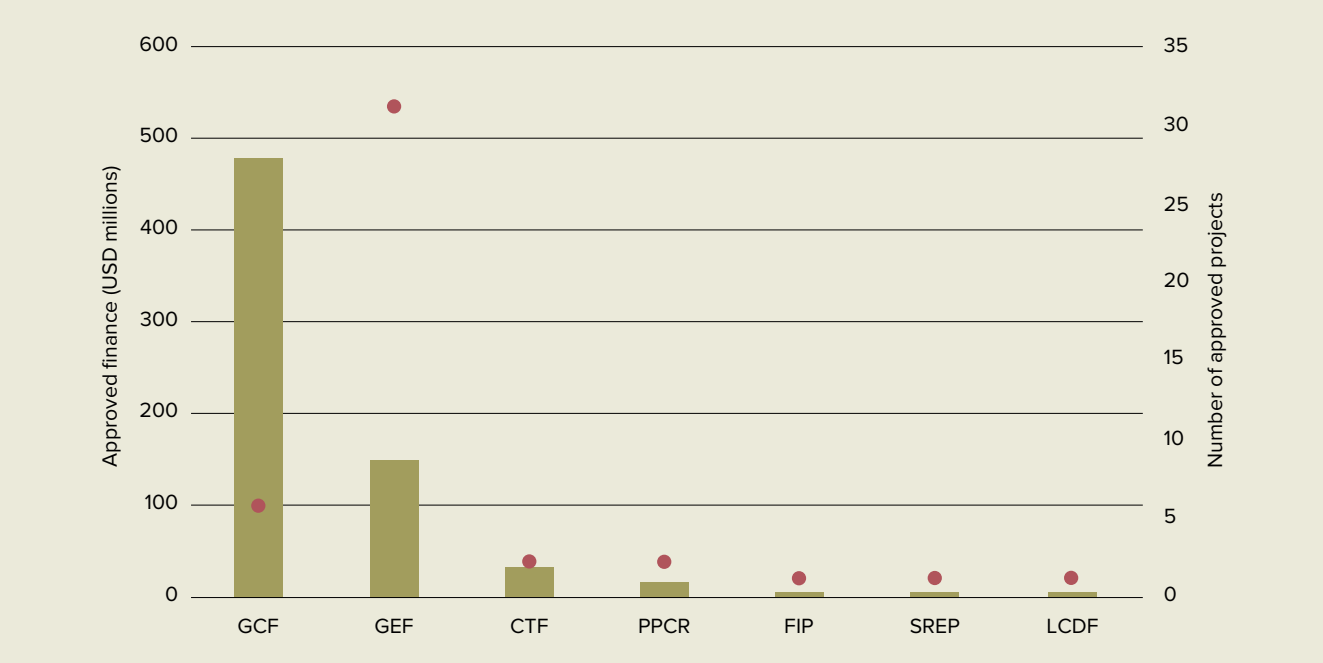
2.2. The contribution of the multilateral climate funds to MSMEs

Gathering quantitative information on the finance flowing to MSMEs from the multilateral climate funds has its challenges. The technical definition of MSMEs in terms of indicators such as number of employees, assets and sales can vary from country to country (SME Finance Forum, 2014) and also by fund. There are often no explicit markers to indicate which projects are targeting MSMEs and to what extent (some projects have MSME engagement as a subsidiary rather than a main objective). As a result, this paper does not provide yet another definition of MSMEs, nor does it propose to judge the definitions proposed by the climate funds. Instead, it takes the term 'MSME' at face value and assumes that MSMEs are being engaged when a fund notes its engagement with either small and medium enterprises (SMEs) or MSMEs. The following steps were taken in an initial effort to assess the contributions of the nine dedicated climate funds presented in Table 1 to climate action by MSMEs:

- The Climate Funds Update[4] database of approved project titles for the analysed fund was searched, as was the fund's own website, for key words (including 'SME', 'small enterprises', 'medium enterprises', 'micro enterprises' and 'small business'). This allowed the provisional identification of projects that explicitly mentioned the financing of MSMEs in their titles and descriptions. Only projects that had been approved or were in advanced stages as proposals were considered.
- Where climate funds had outlined specific priorities, such as to increase financing to the private sector or to engage

[4] The Climate Funds Update (www.climatefundsupdate.org) is an independent website run by ODI and the Heinrich Boell Foundation to monitor the pledges, deposits, approvals and disbursements of climate finance through a number of major dedicated multilateral climate funds.

Figure 1. Approved climate finance for MSMEs by multilateral climate fund

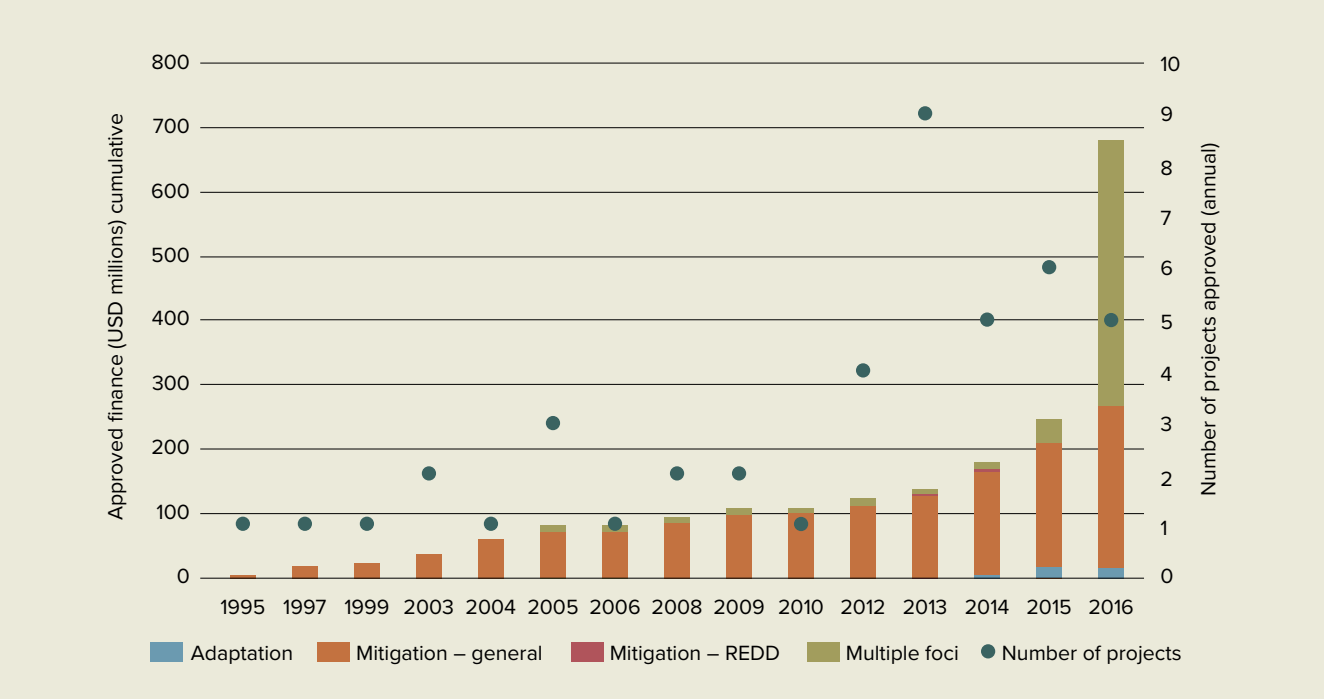


with MSMEs, these were explored to find any initiatives taken under these priorities, and consequently projects that had been approved, or in the process of approval, through these channels.

- Projects where resources were directed at MSMEs, though not as a core objective, were not included. For example, although a recently approved GCF project in Samoa to increase resilience to flooding in the Vaisigano river catchment area noted that assistance will be provided to business incubation for small-medium and micro agribusiness that develop ideas for flood-risk management-related businesses, this was not considered a sufficiently significant component of the project to be included.
- For projects that were determined to be supporting MSME action, the total figure for approved finance was collected. This captures the finance provided by the climate funds, but not co-finance. For example, the total project financing for the GCF's Sustainable Energy Financing project will be $1,400 million USD, of which $378 million is being provided by the GCF as concessional funding and grants, while the remaining amount is being provided by the EBRD and other bilateral and multilateral donors.

It is recognized that, as a first attempt, this method may omit projects that engage with MSMEs less explicitly or as a small component of a larger project. Climate funds that have as their core objectives climate change adaptation or mitigation may have projects that focus on livelihoods, but it may not be clear that this aspect includes engagement with MSMEs. Thus, this paper is likely to underestimate the level of the involvement of multilateral climate funds with MSMEs. Challenges also arise in attributing each project to either mitigation or adaptation respectively. While some projects define their own themes, others are harder to define or could include adaptation activities. For instance, many energy-efficiency projects are categorized as mitigation projects, yet they contain components that also promote resilience to climate change. For example, the GCF's SCF Capital Solutions Programme, a South Africa-based programme created to support start-ups in renewable energy and energy efficiency sectors, is labelled a mitigation project. Investment in renewable energy start-ups will increase energy access, as well as create 6000 jobs. Targeting 45% of its financing at women, 35% at young entrepreneurs and 70% at owners who were previously disadvantaged individuals, the project can consequently increase the resilience of these groups to climate risks. It is also worth noting that initiatives exist outside these nine funds that may be making significant contributions. The Inter-American Development Bank's Pro

Figure 2. Spending by multilateral climate funds on MSMEs over time



Adapt Fund, for example, mobilizes private-sector finance to promote climate resilience.

Since 1995, the nine funds in Table 1 have collectively approved 44 projects for both mitigation and adaptation, programming $681 million to climate action in MSMEs. This is less than 6% of the total finance approved through these multilateral climate change funds (excluding GEF Trust Funds 1, 2 and 3). The greatest contribution to MSMEs comes from the GCF (Figure 1). With just five projects directly contributing to MSMEs, this largely results from its approval in 2015 of the $378 million project to support Sustainable Energy Financing Facilities. Led by the European Bank for Reconstruction and Development (EBRD), the project will on-lend finance to partner financial institutions in developing countries, thus creating credit lines and self-sustaining markets for energy efficiency, renewable energy and climate resilience. In contrast, the GEF has the highest number of projects (31) that engage MSMEs. The GEF has consistently programmed finance to MSMEs annually. However, total approved finance to these projects is more than three times less than that programmed to GCF-supported projects.

Figure 2 indicates a steady increase in funding to MSMEs over time, with a more rapid rise in the last two years as the GCF has become operational. A jump in the number of projects approved can also be seen in 2013, reflecting the UNIDO Cleantech Programme for SMEs under GEF Trust Fund 5. A competition and incubation pilot, the UNIDO Cleantech Programme, fostered clean technology innovation and provided grants to several countries, namely Armenia ($550,000), India ($1 million), Malaysia ($990,000), Pakistan ($1.37 million), South Africa ($1.99 million), Thailand ($1.83 million) and Turkey ($990,000). The project supported MSMEs by providing not only grant funding, but also to extensive training and mentoring, showcases, materials, and an online global platform that connects entrepreneurs to mentors. This facilitation of knowledge transfer provides a capacity-building function, as well as stimulating local entrepreneurship and the development of MSME policy frameworks. The engagement of entrepreneurs through the Global Cleantech Innovation Programme has since matured and evolved to cover eight countries.[5]

Approved finance from the climate funds for MSMEs has targeted mitigation activities. Adaptation commands less than 3% of finance flowing to MSME activities through three projects (Figure 3), two funded by the PPCR, one by the

[5] See for example: http://www.unido.org/environment/o591190/climate-policies-and-networks/global-cleantech-innovation-programme.html; http://www2.cleantechopen.org/gef-unido/

LDCF. The PPCR projects are in Bangladesh and Tajikistan. In Bangladesh, the 'Climate Smart SME Financing' project, approved in 2015, is being implemented by the IFC, with $10 million in concessional loans to invest in SMEs that are developing climate-smart agricultural technologies and practices. The program is the second component of the IFC-managed PPCR Program; the first part, *Promoting Climate Resilient Agriculture and Food Security*, provided advisory services to private-sector companies to pilot climate-smart technologies and practices. The investment component aims to address three market barriers: the unwillingness of financial institutions to lend and of the private sector to invest in a novel topic without a proven business model; the limited range of financial products targeted at SMEs; and the need to increase the SME's business skills, operational and financial reporting capacity, and lack of collateral. The 'Small Business Climate Resilience Financing Facility' in Tajikistan which was approved in 2014, is being implemented by the EBRD and is to receive $5 million in concessional funding. It aims to increase the uptake of climate-resilient, water-efficient and energy-efficient technologies by small businesses, farmers and households through the provision of special-purpose intermediated finance. This includes targeted credit lines via public finance institutions and is being supported by technical assistance facilities.

In 2015, the LDCF approved a project in Gambia that engages MSMEs dependent on coastal fisheries. It is providing $2.2 million in grant funding towards the $7.7 million project being implemented by UNDIO. Its intention is to increase the adaptive capacities and resilience of coastal fisheries and dependent populations and enterprises by mainstreaming, demonstrating and scaling up climate resilient business models for value addition and employment throughout the fisheries value chain.

It is worth acknowledging that two proposed Adaptation Fund projects are explicitly targeting MSMEs. At the start of 2017, the Adaptation Fund had two upcoming adaptation projects taking MSMEs into account. The first, based in Central America, is seeking $5 million in grant finance to build capacity to implement adaptation measures in micro, small and medium agricultural enterprises by providing technical assistance in adaptation planning processes and incentives for the specific alternatives of resilience and investment management options[6] (Adaptation Fund, 2017). The second project seeks $10 million in grant finance to build watershed and built environment resilience to heavy rainfall in Antigua and Barbuda. It includes efforts to target financial assistance to MSMEs as a key 'community' stakeholder[7] (Adaptation Fund, 2016).

Furthermore, the GEF has recently undertaken an internal targeted analysis of its own adaptation portfolio to determine the extent to which private-sector entities are engaged in LDCF and SCCF projects. It has uncovered many more projects in their evaluation than have been identified through this method, suggesting that MSMEs are the beneficiaries of activities to support entrepreneurship and value chain development, including through training, capacity-building and other types of technical assistance. Specifically, the groups targeted consist of farmers' associations, village cooperatives and community-based organizations. Although claiming that as much as 90% of their adaptation portfolio supports private-sector actors, this finding is not replicated in this paper. This reflects both the difficulties in assessing the extent to which projects engage with MSMEs from project titles and summaries alone and in determining the threshold at which a smallholder becomes a profit-generating entity.

A full 86% of projects identified supported climate change mitigation (Figure 3). However, a small number of projects addressing both mitigation and adaptation (cross-cutting or multiple-foci) have captured most of the approved finance, 61% of which is identified as flowing to MSMEs. Mitigation commands 37% of finance for MSMEs. This results from the two 2015 project approvals by the GCF, the aforementioned Sustainable Energy Financing Facilities project and the KawiSafi Ventures Fund, both labelled as addressing adaptation and mitigation objectives. The KawiSafi Ventures Fund project, being implemented by the Acumen private equity fund, will finance early-stage MSMEs with core business models in the context of the off-grid solar ecosystem in East Africa by providing seed capital for 10-15 MSMEs in the form of equity. In this

[6] The Productive Investment Initiative for Adaptation to Climate Change project aims to support Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Dominican Republic. The project will be implemented by CABEI, the Central American Bank for Economic Integration.

[7] The proposed Integrated approach to physical adaptation and community resilience in Antigua and Barbuda's northwest McKinnon's watershed project will be implemented by the Department of Environment, Ministry of Health and the Environment, of Antigua and Barbuda.

Figure 3. Share of projects and share of funding to MSMEs from multilateral funds by theme

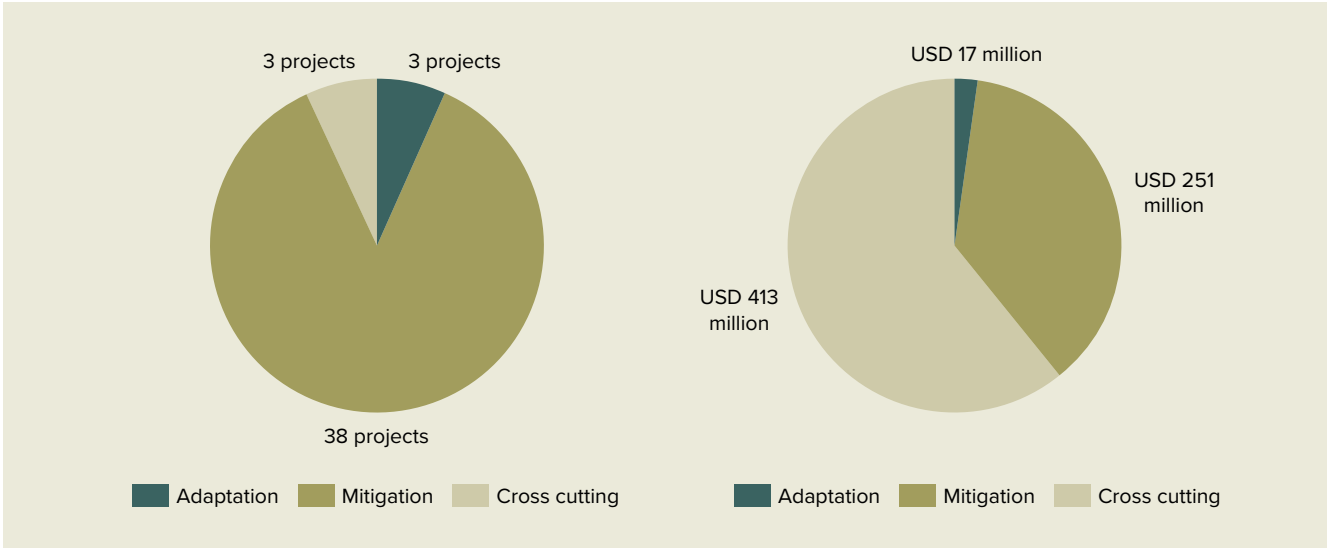
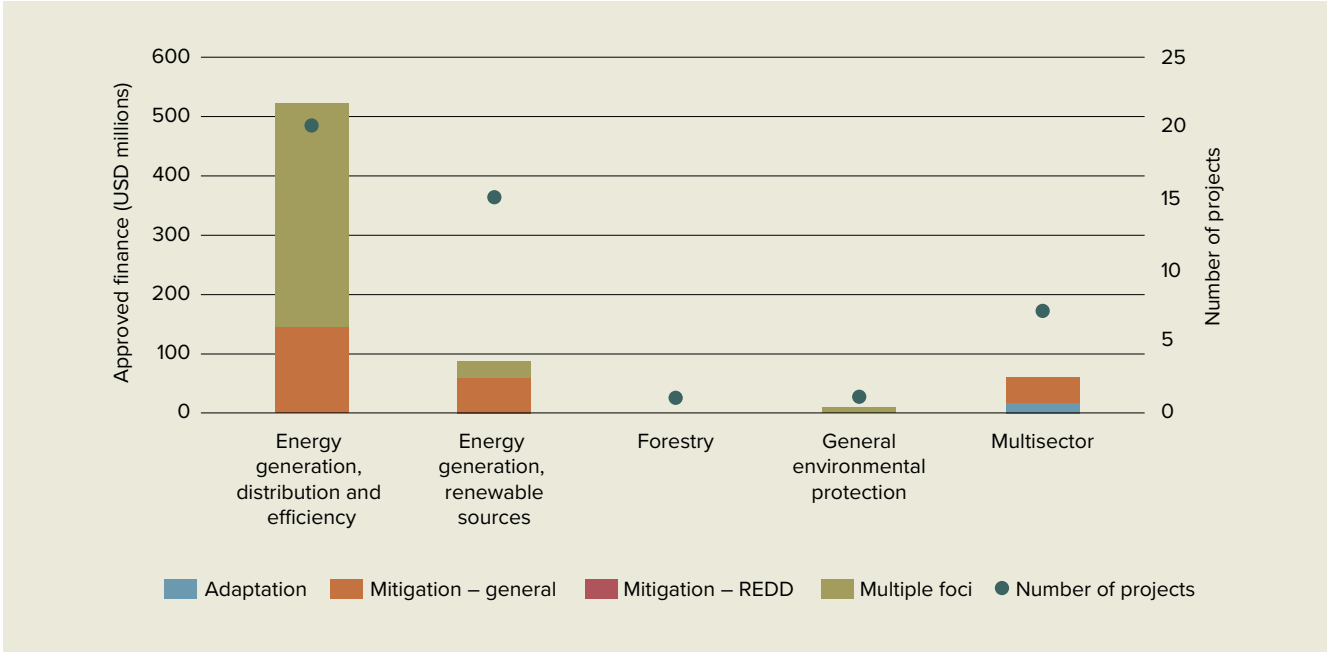


Figure 4. Projects approved by climate funds for MSMEs by sector



project, the GCF assumed first-mover risk so as to crowd in other private finance.

The GCF's results framework is focused on seeking projects that have development objectives and that aim to deliver on both mitigation and adaptation. This reflects the inherent and possibly unnecessary difficulty of separating adaptation actions from good development. However, further analysis reveals that the bulk of projects supporting MSMEs are in the energy sector (Figure 4). This reflects a valid need to support the greening of the energy sector as part of the global response to climate change. Adaptation actions *are* found in the energy efficiency sector, and the crosscutting project focus is progressive for the climate funds. Nonetheless we must not let this obscure the fact that adaptation finance for MSME action is much lower than for mitigation,

Figure 5. Map of the funding approved by multilateral climate funds for MSMEs, excluding funding approved for global and regional projects amounting to $463 million

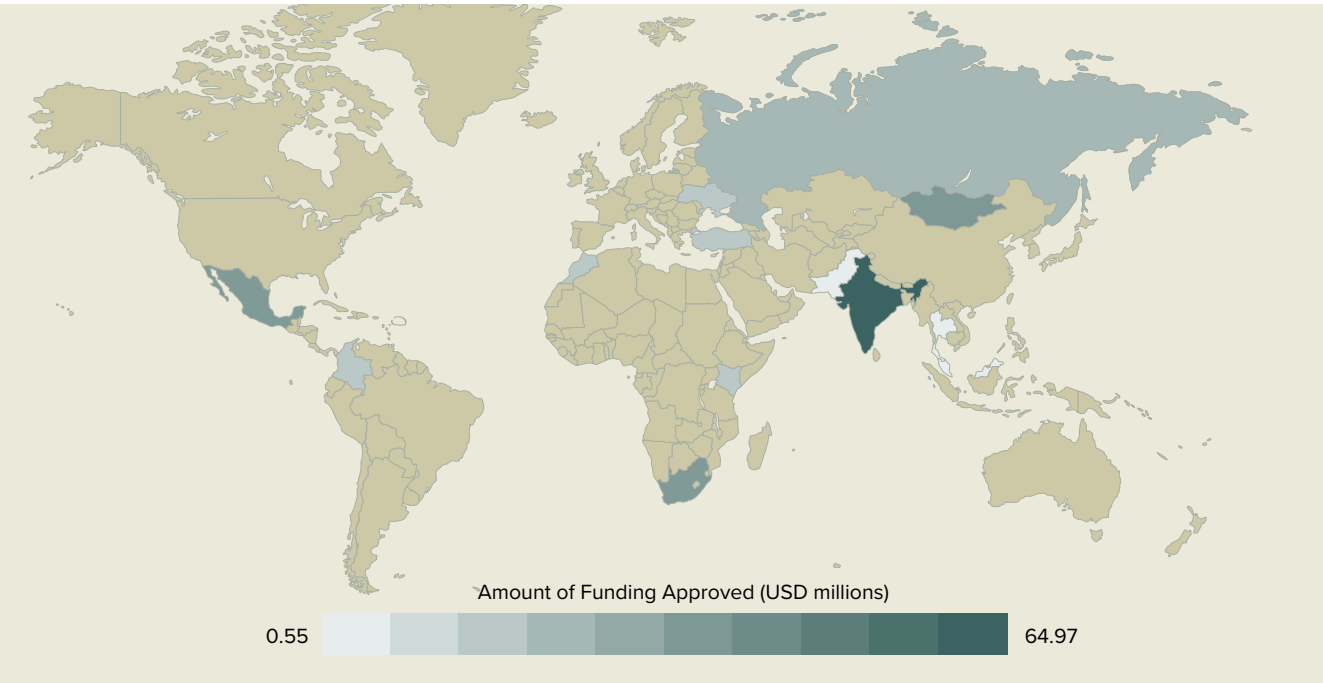
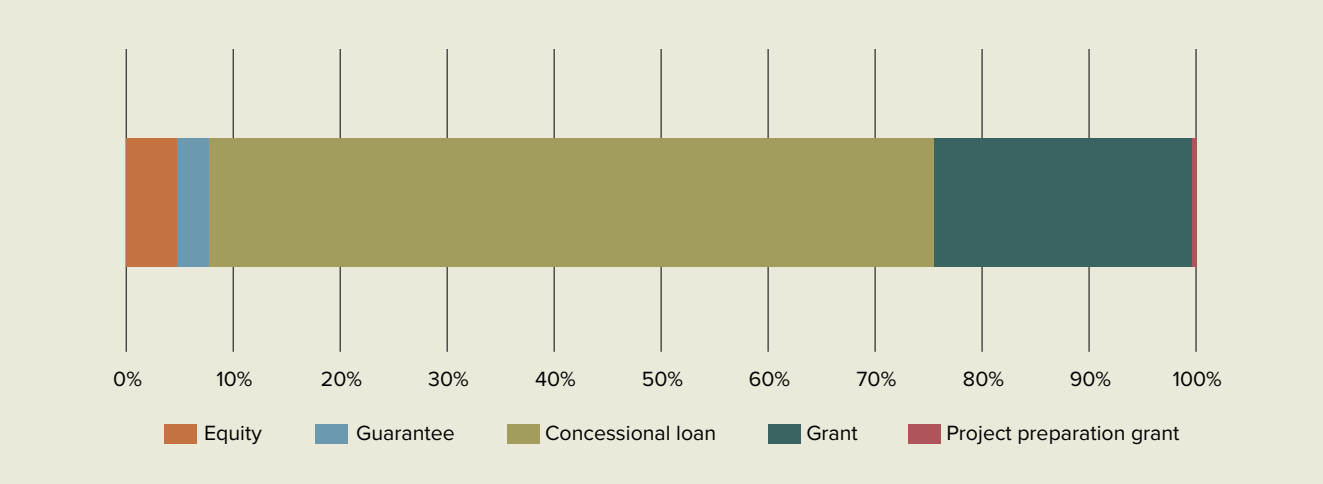


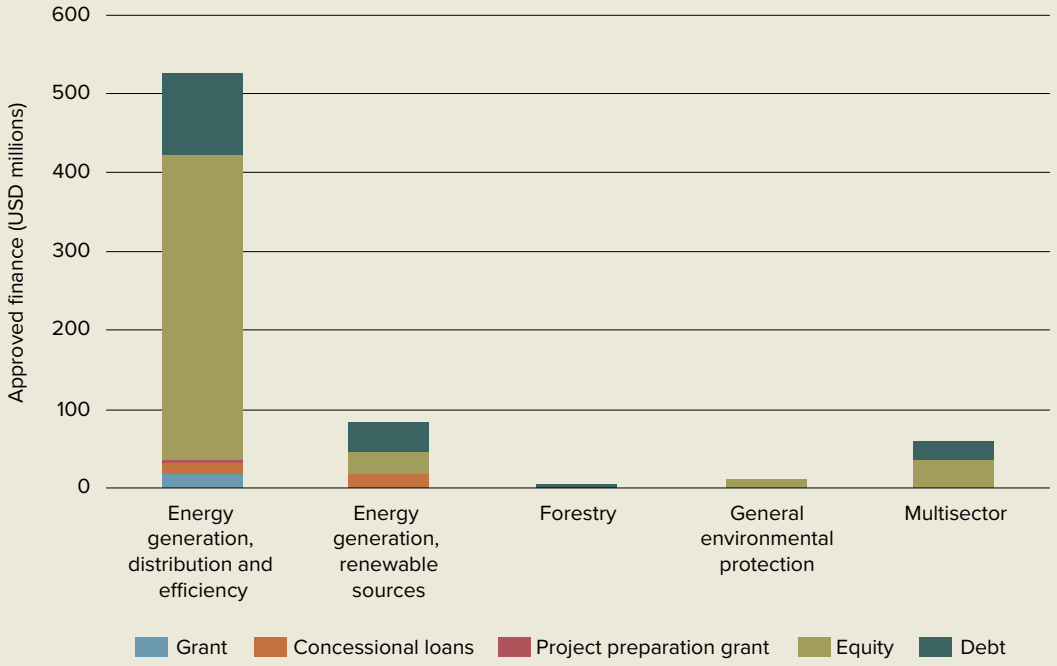
Figure 6. Financial instruments of approved funding for MSMEs from the multilateral climate funds



and it remains unclear just how much will be available through cross-cutting projects for adaptation. This finding is reflective of a broader bias towards mitigation in the portfolios of the multilateral climate funds (see Nakhooda et al., 2014).

The geographical distribution of MSME projects funded by the multilateral climate funds shows that the largest amount of approved funding (63%) is for global activities, taken to mean projects that involve countries in three or more regions. A further 5% of funding is for regional activities, taken to mean projects that operate in more than one country in a region or that target the region as a whole (Figure 5; Appendix I). Figure 5 identifies the individual countries that have benefitted from climate fund approvals for MSMEs. India has received $65 million from nine projects, all energy-

Figure 7. Financial instruments of approved funding for MSMEs by sector



related projects targeting energy efficiency and renewable energy and led by GEF. While the number of projects is too small to make judgements on the distribution or allocation of finance to MSMEs, the domination of middle-income countries is clear. Further work may be needed to identify the specific needs or means to increase support for climate action for MSMEs in low-income countries.

To date, the majority of funding flowing through the multilateral climate funds monitored by the Climate Funds Update has been programmed in the form of grants. This is particularly true for adaptation finance (UNFCCC, 2016; Nakhooda et al., 2016). In contrast, however, of the finance flowing to MSME activities identified here, more than two-thirds was programmed as concessional loans. Grants, including those for project preparation, comprised just less than a quarter, equity and guarantees together less than 9% (Figure 6 and 7). The domination of concessional loans is perhaps predictable, given the private-sector nature of the engagement and the expected returns from operations. Yet grants for capacity-building and technical assistance must continue to complement such funding. In addition, where their operating principles permit it, the funds do need to broaden the use of financial instruments in order to reduce risk, for example, encouraging the use of equity and guarantees as part of an approach to increase MSME climate action.

3. Unlocking greater adaptation actions in MSMEs through the multilateral climate funds

Climate action by MSMEs is being supported by the multilateral climate funds, albeit in relatively small but increasing volumes, as shown by this analysis. The most sustained engagement has been by the GEF, partly also due to its longevity. This support focuses on training, capacity-building and other types of technical assistance that concessional finance, largely in the form of grants, is well suited to support. The relatively recent operationalization of the GCF has increased dramatically the potential volumes of finance to support climate action by MSMEs. Through its implementing entities, some GCF projects will reduce barriers by making non-grant finance available directly to support MSMEs, in addition to more traditional technical assistance. Other funds have become involved to a lesser degree, in most instances resulting from the fund's core remit. For example, they are unable to offer financial

instruments beyond grants, and they do not have, or have not had, ambitions or expertise in mobilizing private-sector finance.

To date, support to MSMEs from the climate funds has been concentrated on renewable energy and energy efficiency. Much less has gone towards agriculture or water, key sectors for adaptation. The increasingly cross-cutting nature of both GCF and GEF projects will go some way towards redressing this balance. There is also the possibility that the method has systematically omitted these projects (see Section 2.2). However, there remains a need for the climate funds to increase adaptation finance for MSMEs, given their remaining vulnerability to climate change, though they can also be the key to locally driven adaptation responses. Any action by the climate funds must, of course, be complemented by state action that supports MSMEs in taking climate action. This might include clarification of climate policies to increase the attractiveness of MSMEs for investors, as well as changes to the tax and regulatory regimes to support the greening of all finance flows, including that to MSMEs.

The climate funds still have a number of planned actions that we are yet to see the results of. The pilot MSME programme of the Green Climate Fund could add as much as $200 million to total approved project flows. This is close to 30% of the existing finance that can be explicitly identified as flowing to this end. If the risk appetite of the GCF is sufficient, this UNFCCC financial mechanism can go further than other climate funds have so far been able. The recent inclusion of MSME actions in project applications to the Adaptation Fund also suggests a shift in the right direction, albeit with much smaller resource caps than the GCF. The GEF internal review of how to increase adaptation actions in the private sector and commitments to this end are other promising moves in the right direction.

For multilateral climate change funds to demonstrate and unlock the opportunities that MSMEs present for climate change adaptation will take more than increased approvals of project finance. The articulation of adaptation with MSMEs was largely missing until the launch of this UNEP DTU Perspective Series. This paper also faces the practical challenge of determining the extent to which multilateral climate funds are engaging with MSMEs. This is not only because adaptation actions remain hard to distinguish from development or because MSME definitions vary by institution and territory, it is also due to a lack of clear articulations of how and why the funds will engage MSMEs, whether directly or indirectly, in climate action. The process of developing pro-MSME policies and investment frameworks for the funds will necessitate further analysis of the key barriers to adaptation actions in MSMEs and a more sophisticated, fund-by-fund articulation of how they can contribute. This is in line with climate funds' efforts to be pioneering and innovative, and it should go beyond the usual limits of commercial and institutional finance in providing start-up or early stage finance and absorbing the associated risks in respect of MSME climate adaptation actions.

Grant finance is and will remain a key component of climate fund support to adaptation action by MSMEs. To date, such finance has made progress in overcoming the challenges faced by MSMEs, such as weak enabling environments and limited knowledge and awareness. It will also be important in meeting additional objectives, such as sustainable development or environmental, social and governance criteria. However, there is an increasing role for financing that is less concessional. As we shift the trillions, and in light of the increasing scrutiny on public spending in contributor countries, the level of the concessionality of finance, even through the climate funds, may be expected to decline (Watson, 2016). However, this can still be aligned with the needs of MSMSEs. The PPCR shows how this may work through the application of concessional first-loss loans that can reduce the actual or perceived high-default risk associated with lending to MSMEs. The application of other financial instruments should also be encouraged in the funds. For example, guarantees or other risk-sharing tools can reallocate the risk of investments from commercial partners to public-sector institutions, while equity can play an important role in the early-stage development of MSMEs, which may face challenges in acquiring bank debt. Along with the PPCR, the GCF has been more willing to use such risk-sharing instruments. Also associated with this expansion of instruments is a shift away from assumptions that adaptation finance should be grant-based only, or that only adaptation as a public good should be supported through these mechanisms. While the politics of the adaptation finance that is flowing through these funds, particularly those of the UNFCCC, should have at their heart the understanding that Annex I countries should support adaptation activities in non-Annex I countries (predominantly the developing countries), grant-based

funding alone will be insufficient to incentivise effective adaptation actions by MSMEs sufficiently.

In expanding the pro-MSME remit of the multilateral climate funds, consideration must also be given to the entities that are being accredited to the funds. The degree to which funds can and do support private-sector, and therefore MSME, adaptation action will also be a product of the accredited and implementing agencies they work through, their expertise and capacity. Across the funds, these accredited entities generally come in a wide range of forms: public and private, and at any scale from sub-national to international. What can be achieved by the funds will also be dictated by which entities are or could be accredited or implementing entities. The multilateral development banks (MDBs) are already accredited to many of the multilateral funds, and they have also made substantial commitments to increasing flows of adaptation finance (OECD, 2016). A quick scaling up of MSME action through the funds could be based on their expertise or work with it. They may be able to support the offering and scaling up of standardized financial products for MSMEs (e.g. micro-loans, or other tailored debt products that allow funding without formal credit ratings), but on preferential terms, or they can support the aggregation of investments that reduce the high transaction costs of working with MSMEs. Yet the greater engagement of local financial, commercial or development-oriented institutions could support more targeted and more context-specific financial products in response to local barriers to MSME climate action (Dalberg, 2015). Once the pros and cons of working through different intermediaries are better established, direct access and simplified accreditation procedures could also be investigated for the funds.

What is still missing if climate funds are to facilitate a quantum leap in the engagement of MSMEs is a strategy to seek greater engagement by the informal MSME sector. In developing countries, the majority of MSMEs are in the informal sector, and reaching them with traditional financial products is complex. If the funds were to make this their niche, showcasing good examples that can be scaled up and replicated in other countries, they could support the innovation of alternative credit worthiness assessments or of collateral sources or aggregations of their operations that could increase access to climate finance. However, a learning by doing approach like this will take time.

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Appendix I:

Identified MSME-directed projects from the dedicated multilateral climate funds

Fund	Country	Name of Project	Theme / Objective	Approved year	Amount of Funding Approved (USD millions)
Global Environment Facility (GEF1)	Global	Small and Medium Scale Enterprise Program	Mitigation	1995	4.30
Global Environment Facility (GEF1)	Global	Small and Medium Scale Enterprise Program	Mitigation	1997	16.50
Global Environment Facility (GEF2)	Kenya	Removal of Barriers to Energy Conservation and Energy Efficiency in Small and Medium Scale Enterprises	Mitigation	1999	3.23
Global Environment Facility (GEF3)	India	Removal of Barriers to Energy Efficiency Improvement in the Steel Rerolling Mill Sector	Mitigation	2003	7.03
Global Environment Facility (GEF3)	Global (21 Countries: global project; global project covering Belize, Bolivia, Chile, Costa Rica, Ecuador, Ethiopia, El Salvador, Ghana, Guatemala, Kenya, Madagascar, Mexico, Mozambique, Indonesia, Peru; country projects in Mongolia, Peru, Tanzania, China, Indonesia, Egypt)	Environmental Business Finance Program (EBFP)	Mitigation	2004	20.00
Global Environment Facility (GEF3)	Regional (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)	Central American Markets for Biodiversity (CAMBio): Mainstreaming Biodiversity Conservation and Sustainable use within Micro, Small and Medium-sized Enterprise Development and Financing	Multiple foci	2005	10.20
Global Environment Facility (GEF3)	Morocco	Promoting Energy Conservation in Small and Medium Scale Enterprises (PECSME)	Mitigation	2005	5.80
Global Environment Facility (GEF3)	Russian Federation	Russian Sustainable Energy Finance Program	Mitigation	2005	7.00
Global Environment Facility (GEF3)	Kenya	Market Transformation for Efficient Biomass Stoves for Institutions and Small and Medium-Scale Enterprises	Mitigation	2006	1.00
Global Environment Facility (GEF3)	Global (Africa: Cameroon, Tanzania, Zambia, Asia: Cambodia, Indonesia, Thailand, Latin America: Honduras, Nicaragua, Panama and other countries pending request.)	Renewable Energy Enterprise Development – Seed Capital Access Facility	Mitigation	2003	8.70
Global Environment Facility (GEF4)	India	Financing Energy Efficiency at Micro, Small and Medium Enterprises (MSMEs)	Mitigation	2008	11.30

Fund	Country	Name of Project	Theme / Objective	Approved year	Amount of Funding Approved (USD millions)
Global Environment Facility (GEF4)	India	IND: Promoting Energy Efficiency and Renewable Energy in Selected Micro SME Clusters in India under the Programmatic Framework for Energy Efficiency	Mitigation	2009	7.27
Global Environment Facility (GEF4)	India	Energy Conservation in Small Sector Tea Processing Units in South India.	Mitigation	2008	0.98
Global Environment Facility (GEF4)	Morocco	Energy Efficiency in the Industrial Sector	Mitigation	2010	2.81
Global Environment Facility (GEF4)	Ukraine	Improving Energy Efficiency and Promoting Renewable Energy in the Agro-Food and other Small and Medium Enterprises (SMEs) in Ukraine	Mitigation	2009	5.25
Global Environment Facility (GEF5)	Armenia	GEF UNIDO Cleantech Programme for SMEs in Armenia	Mitigation	2013	0.55
Global Environment Facility (GEF5)	India	GEF UNIDO Cleantech Programme for SMEs in India	Mitigation	2013	1.00
Global Environment Facility (GEF5)	Malaysia	GEF UNIDO Cleantech Programme for SMEs in Malaysia	Mitigation	2012	0.99
Global Environment Facility (GEF5)	Pakistan	GEF UNIDO Cleantech Programme for SMEs in Pakistan	Mitigation	2013	1.37
Global Environment Facility (GEF5)	South Africa	GEF UNIDO Cleantech Programme for SMEs in South Africa	Mitigation	2013	1.99
Global Environment Facility (GEF5)	Thailand	GEF UNIDO Cleantech Programme for SMEs in Thailand	Mitigation	2014	1.83
Global Environment Facility (GEF5)	Turkey	GEF UNIDO Cleantech Programme for SMEs in Turkey	Mitigation	2013	0.99
Global Environment Facility (GEF5)	India	Organic Waste Streams for Industrial Renewable Energy Applications in India	Mitigation	2013	3.41
Global Environment Facility (GEF5)	South Africa	Promoting Organic Waste-to-Energy and other Low-carbon Technologies in Small and Medium-scale Enterprises (SMMEs): Accelerating Biogas Market Development	Mitigation	2014	4.22
Global Environment Facility (GEF5)	India	Promoting Business Models for Increasing Penetration and Scaling up of Solar Energy	Mitigation	2012	4.45
Global Environment Facility (GEF5)	India	Promoting Market Transformation for Energy Efficiency in Micro, Small and Medium Enterprises	Mitigation	2012	4.54

Fund	Country	Name of Project	Theme / Objective	Approved year	Amount of Funding Approved (USD millions)
Global Environment Facility (GEF5)	Thailand	Greening Industry through Low Carbon Technology Application for SMEs	Mitigation	2014	1.91
Global Environment Facility (GEF5)	Turkey	Small and Medium Enterprise Energy Efficiency Project	Mitigation	2012	3.64
Global Environment Facility (GEF5)	Albania	Biomass Energy for Productive Use for Small and Medium Enterprises (SMEs) in the Olive Oil Sector	Mitigation	2013	0.98
Global Environment Facility (GEF6)	Turkey	Promoting Energy-Efficient Motors in Small and Medium Sized Enterprises (SMEs)	Mitigation	2015	3.85
Global Environment Facility (GEF6)	Tajikistan	Green Energy SMEs Development Project	Mitigation	2016	2.59
Least Developed Countries Fund (LDCF)	Gambia	Strengthening Adaptive Capacities to Climate Change through Capacity Building for Small Scale Enterprises and Communities Dependent on Coastal Fisheries in The Gambia	Adaptation	2015	2.20
Forest Investment Program (FIP)	Mexico	Support for forest related micro, small and medium-sized enterprises (MSMEs) in Ejidos	Mitigation	2013	3.00
Clean Technology Fund (CTF)	India	Partial Risk Sharing Facility for Energy Efficiency	Mitigation	2014	25.00
Clean Technology Fund (CTF)	Colombia	Innovative Instruments to Foster Energy Efficiency in SMEs in Colombia	Mitigation	2015	4.52
Scaling-Up Renewable Energy Program for Low Income Countries (SREP)	Honduras	Sustainable Rural Energization (ERUS), Part I & III: Promoting Sustainable Business Models for Clean Cookstoves Dissemination	Mitigation	2013	2.95
Pilot Programme for Climate and Resilience (PPCR)	Bangladesh	Climate Smart SME Financing	Adaptation	2015	10.00
Pilot Programme for Climate and Resilience (PPCR)	Tajikistan	Small Business Climate Resilience Financing Facility	Adaptation	2014	5.00
Green Climate Fund (GCF)	Mongolia	Business loan programme for GHG emissions reduction	Mitigation – general	2016	20
Green Climate Fund (GCF)	South Africa	SCF Capital Solutions	Mitigation – general	2016	12.2
Green Climate Fund (GCF)	Regional – Sub-Saharan Africa (Rwanda, Kenya)	KawiSafi Ventures Fund	Multiple foci	2015	25
Green Climate Fund (GCF)	Mexico	Energy Efficiency Green Bonds	Mitigation – general	2015	22

Fund	Country	Name of Project	Theme / Objective	Approved year	Amount of Funding Approved (USD millions)
Green Climate Fund (GCF)	El Salvador	Energy Savings Insurance (ESI) for Private Energy Efficiency Investments by Small and Medium-sized Enterprises	Mitigation – general	2016	21.7
Green Climate Fund (GCF)	Global (Armenia, Egypt, Georgia, Jordan, Moldova, Mongolia, Morocco, Serbia, Tajikistan, Tunisia)	Sustainable Energy Financing Facilities	Multiple foci	2016	378

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Multistakeholder partnerships for adaptation: the role of micro, small and medium enterprises

Abstract

SMEs are of overwhelming importance for developing countries' economies and labour markets. In the context of the great need for climate change adaptation and the 'adaptation finance gap' between the costs of adaptation and the level of international support provided to developing countries, this chapter analyses the potential of multi-stakeholder partnerships as a vehicle for SME engagement in adaptation. Recent years have shown a stark increase in such partnerships as a way of addressing climate change. In this chapter, we analyse them with respect to the Lima Paris Action Agenda (LPAA), Momentum for Change, and the Non-State Actor Zone for Climate Action (NAZCA), as well as business cases under the Private Sector Initiative, drawing on both academic and non-academic publications.

Our analysis shows that so far, the initiatives on such platforms have focused predominantly on mitigation and that participation by SMEs in adaptation partnerships is low. This may indicate that partnerships' adaptation activities are not embedded in the local economy and institutions and are not necessarily benefitting SMEs and other local stakeholders. Part of this problem may be caused by the 'adaptation paradox'. Mobilizing partnerships has occurred systematically in the high-level and global political contexts of summits and UN climate negotiations, whereas vulnerability is experienced locally, and adaptation needs to be implemented locally.

SMEs could, however, become an intermediary between the global level and local communities. For this to happen, donor countries should facilitate the participation of SMEs in localized partnership processes, stimulate access to (financial) resources, enhance local knowledge and raise awareness of adaptation.

1. Introduction

Small and medium-sized enterprises (SMEs) are of overwhelming importance to developing countries. They account for more than 90% of all firms outside the agricultural sector (Hussain, Farooq, & Akhtar, 2012), and in many countries they make up the largest economic sector. This Perspectives publication discusses whether SMEs can play a large role in developing countries' efforts to adapt to climate change. This publication has shown that MSMEs face barriers to resilience-building efforts (including limited resources, lack of knowledge and adaptive capacity and unsupportive policies (see Chaudhury in section A2)). However, it also demonstrates that there are some key opportunities for MSMEs in developing countries to develop local capacities in resilience, create livelihoods and contribute to larger efforts towards adaptation provided that these MSMEs get the right support (see Wilson in section A.3).

This chapter focuses on multi-stakeholder partnerships and their potential to stimulate adaptation interventions in the Global South. Such partnerships can be public-private or private-private (PPP) and can take many different forms, as we will explain in section 3. In this publication, we ask whether multi-stakeholder partnerships have potential as a vehicle for SME engagement.

SMEs face formidable challenges in making adaptation efforts. For instance, they often encounter difficulties in accessing market-based finance, and publicly financed adaptation projects may prefer working with larger firms that have international networks and experience. Beck and Demirguc-Kunt (2006) conclude from a survey of 10,000 firms in eighty countries that the size of firms is a major determinant of financing obstacles to them, with smaller firms facing larger constraints. Gardiner, Bardout, Grossi, and Dixson-Declève (2015) look at cooperative initiatives and partnerships on climate finance and find that mitigation efforts attract the large majority of public-private climate finance. This imbalance could be explained by the limited robustness of the business case for adaptation activities, as profitability and risk management are often not clear.

Little knowledge currently exists on the potential role of partnerships when it comes to adaptation by, and with, SMEs. This chapter discusses this issue in detail. It starts with an overview of approaches and definitions of partnerships in the context of sustainable development and addressing climate action. Secondly, it analyses SME participation in partnerships on adaptation based on some of the largest databases on climate action in the private sector, including the Lima-Paris Action Agenda and the UNFCCC's Private Sector Initiative, as well as additional examples found in the literature. Thirdly, we discuss the effectiveness of adaptation partnerships with SMEs. The conclusion summarizes the main messages and provides ideas for stimulating partnerships with SMEs on adaptation.

2. Multi-stakeholder partnerships: approaches and definitions

Multi-stakeholder partnerships have long been seen as a promising instrument for leveraging capacities beyond state level in order to realize sustainable development globally (Pattberg, Biermann, Chan, & Mert, 2012; Szulecki, Pattberg, & Biermann, 2012). We define multi-stakeholder partnerships as governance arrangements that involve at least one public and at least one private organization and that aim to produce collective goods. Prominent examples of such partnerships include, for instance, 'Refrigerants, Naturally!', in which beverage companies work with NGOs and international organisations to replace harmful fluorinated gases.[1] However, our own definition excludes partnership initiatives that bring together partners of the same type to address issues concerning climate change, such as the C40 alliance of cities[2] or the We Mean Business alliance of corporations.[3]

The advantage of multi-stakeholder partnerships is that they pool resources, thus theoretically allowing each partner to play to its strengths. For instance, partnerships between businesses and NGOs combine the scale and market influence of companies with the legitimacy of NGOs to achieve a greater and credible impact. In recent years, such collaborative arrangements have also been pushed for in international climate change governance. For example, the website of the UNFCCC features a 'Portal on International Cooperative Initiatives' pertaining to 'cooperative climate actions undertaken around the world at various levels by

[1] Refrigerants, Naturally! is taking action against global warming and ozone layer depletion. It is a global, non-profit initiative of companies in the food and drink, food service and consumer goods sectors, including corporate members such as PepsiCo, Red Bull and Unilever. Greenpeace and UN Environment are supporters of the initiative (see http://www.refrigerantsnaturally.com/).

[2] C40 is a global network of cities committed to addressing mitigation and adaptation (See http://www.c40.org/)

[3] We Mean Business is a coalition of organisations working with thousands of businesses that 'recognize that the transition to a low carbon economy is the only way to secure sustainable economic growth and prosperity for all' (see http://www.wemeanbusinesscoalition.org/).

governments, international organizations, civil society, and business that contribute to reducing greenhouse gas emissions'.[4] Similarly, the UNEP DTU Partnership administers a 'Climate Initiatives Platform' with more than two hundred climate initiatives 'driven by non-state actors such as businesses, cities, and regions'.[5] In 2014, the Lima-Paris Action Agenda, a joint initiative by the UN Secretary General, the UNFCCC Secretariat and consecutive UNFCCC COP presidencies Peru and France, presented the 'Non-state Actor Zone for Climate Actions'. This online platform has over 12,000 actions currently registered, both individual and cooperative, in both the mitigation of greenhouse gases and climate change adaptation.

Although multi-stakeholder partnerships might contribute to the implementation of the Paris Agreement, the link between partnerships and intergovernmental processes is often weak. Ideally, the goals of the partnerships complement internationally agreed goals, but they can also replace them or even contradict them. In mitigation, if a partnership would cause rising emissions, this already indicates that it would contradict intergovernmental processes. In adaptation, such an easy proxy is not available. It is important to understand better how partnerships in adaptation can complement international adaptation efforts, for instance, under the UNFCCC. The UN climate negotiations now acknowledge that adaptation to climate change is as important as the mitigation of greenhouse gasses (UNFCCC, 2008, 2015). However, the available public adaptation finance falls short of the needs (UNEP, 2016). Additional efforts can be leveraged from different stakeholders either in cooperation with (inter-)governmental agencies or independently in at least six ways.

First, **partnerships could leverage additional finance to support (developing) countries with adaptation.** The estimated annual adaptation finance needs for developing countries in 2015 were already in the range of US$50 billion (Baarsch et al., 2015). Globally, the costs of adaptation are estimated to rise US$ 280 to US$ 500 billion by 2050 (UNEP, 2016). International climate finance efforts, however, are currently not enough to address adaptation needs satisfactorily. The OECD estimate of private and public finance mobilized in 2014 amounted to about US$ 62 billion (OECD, 2015). This figure is highly disputed, however, and only one sixth of it was destined to support adaptation (see Ciplet, Roberts, & Khan 2015). Over time, the gap between adaptation costs and the supply of international adaptation finance in the context of the UN climate negotiations is likely to grow wider.

Second, adaptation partnerships could contribute to **implementation on the ground**. In contrast to mitigation efforts, which are globally distributed, adaptation activities are often locally embedded, offering local public goods. In cases where adaptation measures mainly yield excludable benefits (such as protection by a dike, usage of climate-resilient crops or water-saving applications), it is a national, a local or even a private interest to achieve effective adaptation. However, adaptation interests are often expressed at the international level, involving powerful, often developed country-based transnational and national actors (Burns & Forrister, 2012; Rübbelke, 2011). Ayers (2011) calls this a 'paradox': vulnerability to the global risks of climate change is experienced locally, and adaptation needs to be implemented and managed on the same level. However, public adaptation finance as embedded in the UNFCCC negotiations is discussed internationally and focuses on international finance and investment.

Third, partnerships could **increase the legitimacy of adaptation interventions** by widening the participation and cooperation of multiple stakeholders locally. Although research on adaptation partnerships is still scarce, research findings on, for instance, sustainable development partnerships suggest that participation by target groups and those entities that implement adaptation actions is likely to contribute to the successful implementation and outcomes of adaptation projects (Pattberg et al., 2012).

Fourth, partnerships have the potential to **increase performance**, having demonstrated their ability both nationally and locally to perform better than purely state-centred governance arrangements. Partnerships could pool the strengths of governments and other actors to deliver on adaptation projects. For instance, for a government a partnership with private-sector partners could help bring in sector-specific expertise and efficient management associated with the private sector.

Fifth, **partnerships can set norms and procedures** where these are lacking internationally and nationally and increase the capacity to, for instance, reduce the impacts of natural

[4] See http://unfccc.int/focus/mitigation/items/7785.php
[5] See http://climateinitiativesplatform.org

disasters. As an example, the Munich Climate Insurance Initiative, initiated as a charitable organisation by insurers, research institutes and NGOs in 2005, supports developing countries in adapting to climate change by using innovative insurance-related risk management tools, often in the absence of a public scheme provided by the government.

Finally, partnerships can **leverage the knowledge** of different stakeholders to enhance adaptation efforts. For instance, a partnership between the International Finance Corporation and a private port facility in Columbia helped to identify vulnerability to rising sea levels, as well as potential adaptation measures. As a direct consequence of this cooperation, the port took out a private loan to implement adaptation measures (Druce, Moslener, Gruening, Pauw, & Connell, 2016).

With all of these potential contributions and the multiple strengths associated with partnerships, it is important to recognize that partnerships are not a panacea. Research on sustainable development partnerships and climate partnerships has shown that they often do not deliver on their promises. 'Partnerships for sustainable development', intended to ensure effective implementation of the internationally agreed Millennium Development Goals, largely failed to deliver relevant outputs and desired environmental and social impacts (Pattberg et al., 2012). Similarly, cooperative climate initiatives launched at the 2014 UN Climate Summit were significantly less successful in developing countries at achieving their stated goals (Chan et al., 2015) (see also the section 'output performance'). Concerns have also been expressed that partnerships may lead to the unwarranted privatization of public responsibilities, especially in developing countries (Chan, 2014). Moreover, multi-stakeholder partnerships do not necessarily lead to greater representativeness or lend a more democratic quality to adaptation governance. For example, partnerships for sustainable development have shown to engage 'usual suspects', namely international organizations, governments, and to a lesser degree NGOs and big business, whereas the participation of vulnerable and traditionally under-represented groups, such as women, unions and indigenous communities, remains marginal (Pattberg et al., 2012). And while it is often clear who leads a partnership and who else is taking part, the exact roles of individual actors often remain unclear.

This section has discussed some of the potential advantages and disadvantages of PPPs. In order to acquire a better understanding of the potential for partnerships with SMEs on adaptation, the following section discusses the evidence regarding partnerships in adaptation, focusing on (1) the platforms and processes in which they are found, (2) the organizational characteristics of these partnerships and (3) the extent to which they are considered beneficial and effective. Subsequently the focus will be on the role of private actors in these partnerships.

3. Evidence of PPPs with SMEs in adaptation

There has been a strong increase in the number of non-state actors, including many businesses, that are taking action on climate change (Chan et al., 2015; UNFCCC, 2017). As this section will show, many are involved in partnership arrangements. International organizations, recent presidencies of the UN climate negotiations, the UNFCCC secretariat and other parts of the UN system have been active in mobilizing such actions. Apart from these examples, the UNFCCC secretariat has also launched the 'Momentum for Change' campaign, the 'Private Sector Initiative' and the recent 'Marrakesh Partnership for Global Climate Action'. These are currently the main platforms for partnerships on climate action. They will all be introduced and analysed in this section, based on the databases we have created (see Pauw, Klein, Vellinga, & Biermann, 2015; Chan & Pauw, 2014; Chan et al., 2015; Chan, Falkner, van Asselt, & Goldberg, 2015). This chapter looks at the extent to which the initiatives cover partnerships that focus on adaptation and include SMEs in particular.

Global Climate Action Agenda

In the context of the UNFCCC process, an increasing number of efforts are being made to promote multi-stakeholder partnerships. Especially in the run-up to the 2015 Paris Agreement, a global climate action agenda took shape with the aim of engaging a high number of non-state actors, including civil-society organizations, investors and businesses.

In 2014, the UNFCCC secretariat published a list of sixty partnerships or 'international cooperative initiatives' that will make mitigation contributions in the period until 2020. By 2016, this list, which is now hosted by the UNEP DTU Partnership, contains 229 cooperative initiatives, many of which feature multi-stakeholder participation and address adaptation. An important 'game-changer' for

non-mitigation partnerships was the UN Climate Summit in New York in September 2014, when the then UN Secretary General, Ban Ki-moon, convened head of states and leaders from business, investors and civil society with the aim of launching partnerships on climate action. Over fifty initiatives were launched at this UN Climate Summit. Moreover, with the addition of two separate 'action areas' on climate resilience (seven initiatives) and agriculture (twenty initiatives), the thematic scope was broadened considerably to include initiatives focused on smallholder farms, as well as adaptation partnerships, among others. The Peruvian and French governments, which presided the UNFCCC in 2014 and 2015 respectively, followed up on these efforts, jointly presenting a 'Lima-Paris Action Agenda' (LPAA). The LPAA aimed to mobilize new initiatives in the run up to the 2015 UN climate conference and to demonstrate the sheer number and scale of climate actions going beyond government involvement in order to put pressure on governments to agree on a new international climate agreement. By December 2015, the LPAA had mobilized seventy large-scale initiatives and almost ten thousand partners from both the public and the private sectors (Galvanizing the Groundswell of Climate Actions, 2015). Although these efforts to mobilize and showcase climate partnerships are high-profile, attract considerable media attention and stimulate interest from a growing community of researchers and policy-makers, these partnerships are only a part of a much wider range of climate actions. The LPAA has also set up an online portal, the 'Non-state Actor Zone for Climate Action' (NAZCA), which currently records over twelve thousand climate actions – with many actions taken individually in addition to partnerships, and about three thousand actions addressing aspects of adaptation or resilience as a main benefit or co-benefit of mitigation.

However, the participation of SMEs in these mobilisation efforts on the global climate action agenda is very limited. Most initiatives do not explicitly target SMEs, nor do they engage them as partners in partnership arrangements. In spite of the emphasis on business participation under the LPAA and at the 2014 UN Climate Summit, business participation in mobilized partnerships is comparatively low, and large multinational corporations are vastly over-represented among participating businesses (Chan et al. 2015).

Nairobi Work Programme on Impacts, Vulnerability and Adaptation

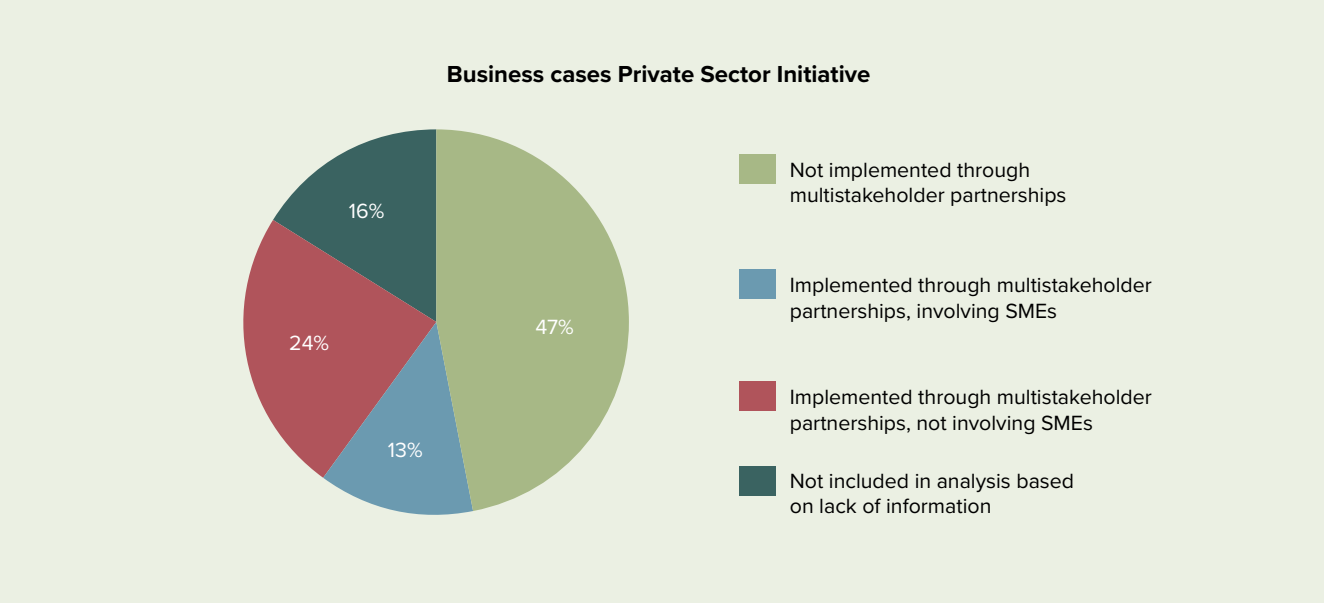
The Nairobi Work Programme on Impacts, Vulnerability and Adaptation, established in 2005 to facilitate and catalyse the development and dissemination of information and knowledge that support adaptation policies and practices, was one of the first international processes to reach out to the private sector in the context of adaptation.

Its most notable example is the **Private Sector Initiative (PSI)**, an online platform for businesses to report and exchange experiences on their contributions to adaptation in their operations, launched in 2010. With 101 initiatives, it provides the only large database of private-sector engagement in adaptation. Consequently, it is often referred to in research (e.g., PwC 2010; Kato, Ellis, Pauw, & Caruso, 2014; Surminski, 2013; Chan & Pauw, 2014; Pauw et al., 2015). The case studies represent private adaptation interventions from all over the world and in all sectors, including water, food and agriculture, transport and infrastructure, and tourism. Most case studies have been implemented by multinationals such as Allianz, Anglo American, GlaxoSmithKline, Nestlé and Siemens, with research institutes and consultancies (Acclimatise, Ecofys), non-profit organizations (EWV, Fonkoze) and public-sector owned companies (Network Rail, ÖBB) being less represented. Only a few SMEs are involved (e.g. Banka Bioloo, Ignita).

The quality of the PSI database, however, is limited because it consists of open and unselective self-submitted business cases. Sixteen of these business cases fail to clarify the adaptation aspects of their efforts, and/or whether their actions involved new or pre-existing commitments. Rather, these examples may have been submitted because they saw an opportunity to advertise their products and services without clearly linking them to the goals of the platform. Of the remaining 85 business cases, a significant number of 37 initiatives (42%) are being implemented through multi-stakeholder partnership arrangements, suggesting that partnerships are important as vehicles for private engagement in climate adaptation. However, only 13 out of these 37 initiatives include SMEs among the partners (see Figure 1).

This low level of participation in partnerships under the PSI does not necessarily suggest a general lack of SMEs involved in adaptation interventions. Instead, PSI's close

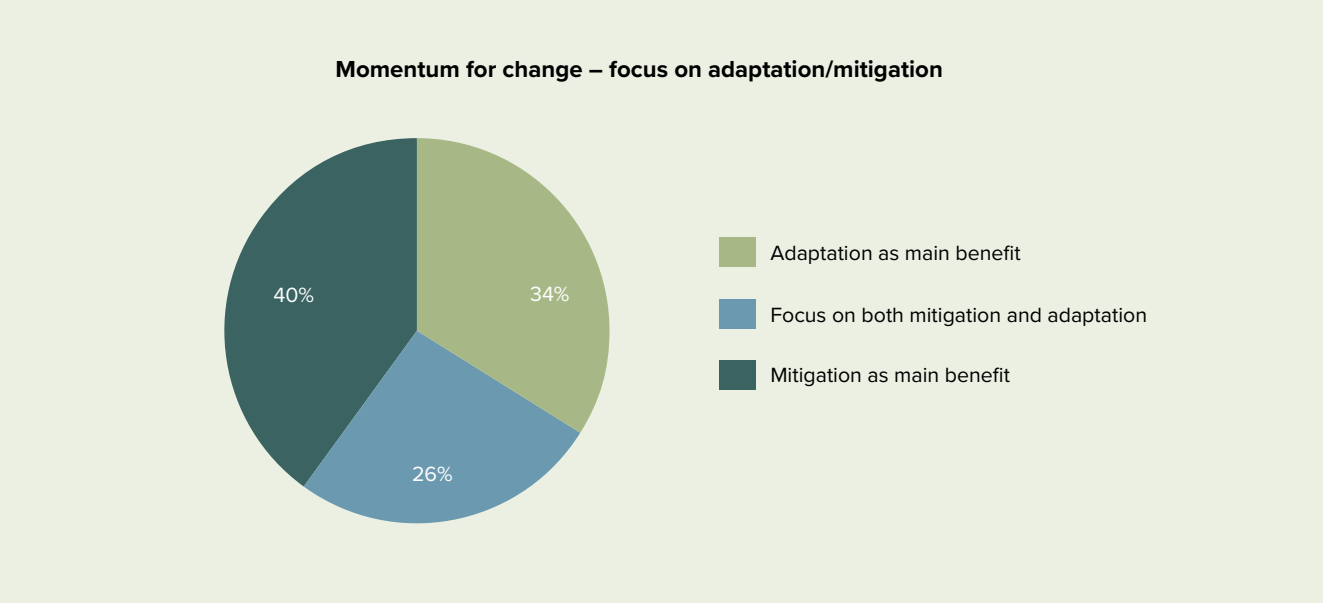
Figure 1. Share of business cases of the UNFCCC's Private Sector Initiative implemented through multi-stakeholder partnerships with SMEs.



connection with the international climate regime and lack of local embedding may explain the lower participation of local actors and SMEs. This explanation would be consistent with the adaptation paradox mentioned above (Ayers, 2011). Subsequently, the integration of local experiences into climate governance at the global level is particularly challenging. Having been conceived in the context of the intergovernmental climate regime, PSI struggles to integrate the local experience of partnerships that involve SMEs for at least three reasons. First, the PSI platform itself may be unknown to partnerships that operate at the local level. Secondly, local-level partnerships that are more likely to feature participation by SMEs might not see the benefits of being featured on global platforms. Finally, SMEs may be more inclined to mainstream adaptation and climate-related activities into their own business planning, for example, by protecting their own assets, improving water efficiency or reducing flood risks. Unfamiliar with climate change, international negotiations and technical terminology, they are often not aware that they may be unknowingly contributing to community-level adaptation through these kinds of activities (Druce et al., 2016; Pauw, 2017). PSI business cases with SME involvement suggest two tentative findings. First, SMEs tend to become involved at the level at which the project is being implemented by acting as intermediaries between larger corporations and local populations. For example, PepsiCo India, Cafédirect and Swiss Re all work with local farmers' organizations to build climate resilience among farmers. Secondly, SMEs typically act as specialized knowledge providers in adaptation planning. For example, GCAP, Waycarbon and CLIMsystems Ltd provide modelling systems for climate change impact and adaptation assessments.

Other SMEs in the wholesale, retail and other sectors such as manufacturing may be more under-represented in the PSI and other platforms than can be explained by the adaptation paradox. Their contributions could be less visible due to the fact that their climate adaptation actions are listed as part of the supply and production chains of, for instance, multinational corporations, rather than as individual contributions. The under-representation of SMEs may also be due to the fact that collaborative adaptation measures (or just reporting of them) are seen as additional burdens which require too much labour and staff. Instead, SMEs might choose to rely on community-level protection, individual property-level protection or risk insurance (Wedawatta & Ingirige, 2012).

Figure 2. The focus of initiatives from Momentum for Change. Source: Eichorn, 2016.



4. Other platforms

Looking at other platforms that record partnerships without being expressly focused on adaptation, we can learn more about the distribution of initiatives across different climate aspects, including adaptation and mitigation. Generally, we observe strong imbalances between mitigation- and adaptation-oriented partnerships.

The UNEP DTU Partnership's 'Climate Initiatives Platform' focuses exclusively on partnerships. The proportion of adaptation-focused initiatives remains very low at only 28 out of 229 (12%). Partly responding to the criticism that 'International Cooperative Initiatives' focus too much on mitigation functions, the 2014 UN Climate Summit set out to redress the imbalance by including 'climate resilience' as one of its main 'action areas.'

A 2014 survey of Momentum for Change initiatives, a campaign by the UNFCCC secretariat to highlight often small-scale climate initiatives with a sustainable development edge, puts the proportion of adaptation partnerships much higher. Of the 52 initiatives that responded to the survey, 34% exclusively or mainly address adaptation, with another 26% addressing both mitigation and adaptation (Eichhorn, 2016). One explanation for the relative higher proportion of initiatives addressing adaptation may be the fact that small-scale initiatives concerned with sustainable development are often more embedded in local governance contexts where vulnerabilities and the need for adaptation are more salient. Widening the focus beyond mitigation partnerships to focus on smaller-scale local initiatives may therefore present an opportunity to engage SMEs in collaborative initiatives.

Unfortunately, SMEs are not recorded as a separate category in the Momentum for Change, LPAA or International Cooperative initiatives. More than 30 percent of businesses involved in the partnership initiatives presented at the 2014 UN New York Climate Summit were among the top two thousand of the world's largest companies, suggesting that, at the very least, large multinational corporations are over-represented in the currently recorded set of climate partnerships. As we have explained in the section on PSI, this may be due to the fact that most important platforms and mobilization efforts focus on the context of international governance, which is more interesting for globally operating multinational corporations.

Additional examples from the academic and non-academic literature

A lack of data hinders us in obtaining a better view of the role of SMEs in adaptation partnerships. To improve our understanding of the potential role of SMEs in adaptation partnerships, we conducted an extensive literature study of partnerships with SMEs on adaptation. For example, in their list of private adaptation case studies, Druce et al. (2016) provide a number of examples of adaptation partnerships. These include a partnership between the Global Environment Facility and a hotel in St Lucia to invest in water reuse and efficiency, micro-finance for ecosystem-based adaptation in Peru and Colombia, and a multi-stakeholder partnership on transferring risk for farmers in Ethiopia. Gardiner et al. (2015) describe Kuala Lumpur's 'Stormwater Management Road and Tunnel' as an example of a successful infrastructure partnership serving both mitigation and adaptation (see Gardiner et al., 2015). A study by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) identifies a 'lack of partnerships', which hampers business development in climate change (Bimesdörfer & Richwien, 2012). The study also mentions a number of partnerships, including ones that provide SMS-based weather forecasts to farmers in India and Indonesia, as well as partnerships in innovative insurance products (partly covered by Druce et al. (2016) too). Crick et al. (2016) describe the creation of multi-stakeholder partnerships as a key element of governance arrangements that can stimulate adaptation by SMEs. However, they found only a few examples in the insurance sector in their case-study countries Senegal and Kenya. The role of SMEs in the partnerships in the abovementioned studies often remains unclear. The many case studies and instances of adaptation measures by SMEs found across non-peer-reviewed literature lead us to believe that current high-profile platforms for non-state engagement in climate action, such as PSI, NAZCA and the global climate action agenda, under-report climate adaptation partnerships that include SMEs. There are probably many more examples of partnerships with SMEs on adaptation, especially at the local level, that remain unrecorded. The examples we found offer too little systemic and comparable data to draw general lessons on the participation of SMEs in adaptation partnerships.

5. Effectiveness of adaptation partnerships

While too little systematic and comparable data exist to derive meaningful correlations between effectiveness and the participation of SMEs in adaptation partnerships, a growing body of literature is addressing the effectiveness of partnerships. Moreover, recent research has identified the output performance of climate initiatives, as well as their ability to mobilize additional finance. This section discusses findings relevant to adaptation partnerships.

Output performance

The question of the effectiveness of multi-stakeholder partnerships is important but particularly challenging. Methodologically, the effectiveness of partnerships is subject to widely differing understandings. For instance, should effectiveness be measured against stated goals, (hypothetical) counterfactuals, in terms of behaviour and/or in changes in environmental indicators? Arguably, the environmental impact of partnerships aimed at the mitigation of greenhouse gases can be measured in, for example, tonnes of abated CO_2 emissions. However, no standard metrics are available for adaptation partnerships.

Chan et al. (2015; 2018) have devised a three-step method to measure minimal effectiveness in a comparative manner over larger samples of climate partnerships. They achieved this by collecting tangible outputs attributable to individual partnership initiatives and by determining to what extent these outputs are consistent with their stated purpose. For instance, partnerships that aim to build the resilience of a local community through training would, at the very least, need to produce seminars and/or textbooks, and/or curriculum(s); in order to achieve any positive change in behaviour or improvement in environmental indicators.

Using this minimal indicator of effectiveness, an initial review of partnership initiatives launched at the 2014 UN Climate Summit suggests that, one year into their operations, 65% score quite well on 'output performance' (producing outputs that fit their functional purposes) (Chan et al., 2015). This is relatively high compared to historical precedents. For example, 43% of Partnerships for Sustainable Development launched at the 2002 Johannesburg World Summit for Sustainable Development still performed poorly against the same measure after ten years (Pattberg et al., 2012). However, among the partnerships launched at the 2014 UN Climate Summit, non-mitigation initiatives were found not to be performing particularly well. While ninety per cent of initiatives in the energy action area, which is dominated by mitigation actions, showed a reasonable to good output performance, seventy per cent of the partnerships in action

areas that are more relevant to adaptation, in particular agriculture and resilience, still had to produce relevant outputs. This stark difference in output performance may be due to the fact that many adaptation-oriented partnerships are rather novel, while more established energy partnerships had a decisive advantage in producing relevant outputs on a shorter term. Indeed, a recent UNFCCC report suggests that climate partnerships are becoming more effective over time (UNFCCC, 2017).

6. Addressing needs and mobilising additional finance

Other measures for effectiveness might include whether and to what extent needs are addressed, and whether additional finance is being mobilized to close the adaptation finance gap (see UNEP, 2016).

There is little or no evidence that adaptation partnerships involving SMEs sufficiently address specific needs in developing countries. At the same time, little additional private finance is being mobilized to close the adaptation finance gap. Given the fact that SMEs face difficulties in accessing finance, it cannot be reasonably expected that SMEs close this gap. Rather, SMEs in developing countries could benefit from better access to financial services before they enable community-level adaptation on a greater scale. Meanwhile, it can be expected that SMEs prioritize the protection of their own assets rather than prioritize partnerships. Consequently, even as a novel instrument, partnerships would still need to rely on more 'traditional' actors, such as bilateral donor organizations, multilateral funds and banks, and governments, to mobilize and access additional resources. Nonetheless, SMEs and other actors still take part in informal mutual help arrangements, which can facilitate adaptation capacity at the community level (Rodima-Taylor, 2012).

7. Conclusion

In recent years, the number of recorded multi-stakeholder adaptation partnerships has increased significantly. This is partly due to the growing number of high-profile processes and platforms launched to mobilize climate actions. However, a cross-platform comparison of samples of multi-stakeholder partnerships reveals a structural under-representation of adaptation compared to mitigation. Only one platform, the 'Private Sector Initiative', specifically focuses on non-state contributions to adaptation. Although the high-level UN Climate Summit, and especially the LPAA, mobilized many more adaptation partnerships, the recent shift in the global climate regime towards greater reliance on multi-stakeholder arrangements could exacerbate imbalances in the realization of mitigation and adaptation actions.

Our discussion has also addressed the potential and actual role of SMEs in multi-stakeholder adaptation partnerships. Generally, participation by SMEs in such partnerships is low. Only thirteen out of the 37 business cases under the Private Sector Initiative that were implemented by multi-stakeholder partnerships included SMEs. SMEs are even less visible in high-profile mobilization platforms and processes, such as NAZCA and LPAA. Rather, the emphasis in terms of business participation in recorded multi-stakeholder arrangements remains on the larger businesses, including many multinationals. This is especially problematic for developing countries, where the need for adaptation is generally more urgent and where SMEs make up a large proportion of their production and labour markets. The low participation of SMEs in recorded multi-stakeholder partnerships may therefore indicate that partnerships' adaptation activities are not embedded in the local economy and institutions, and are not necessarily benefiting SMEs and other local stakeholders.

The low participation by SMEs in multi-stakeholder partnerships may have several explanations. First, it may be linked to their own lack of access to (financial) resources, especially in developing countries. Related to this, their small size and limited experience with relatively novel instruments and topics place further limitations on their participation in multi-stakeholder arrangements. Rather than participating in partnerships and enabling community-level adaptation capacity, SMEs prioritize the protection of their own assets. Finally, most recorded adaptation partnerships are initiated by traditional actors in the international climate regime, such as international organizations, multinationals and donor organizations, which generally have limited access to, and knowledge of, SMEs in developing countries. The mobilization of partnerships has occurred systematically in the high-level political contexts of summits and UN climate negotiations, whereas vulnerability is experienced locally, and adaptation needs to be implemented locally.

One could ask whether the low participation of SMEs in partnerships matters? On the one hand, one could argue that the benefits that partnership can bring, such as narrowing the adaptation finance gap and implementing

adaptation activities, are necessary and that SMEs cannot be neglected in the context of developing countries, where they constitute the largest share of economies and job markets. On the other hand, the effectiveness of currently recorded adaptation partnerships could be called into question. There are very few studies of the effectiveness of multi-stakeholder partnerships in climate change, and the little evidence that does exist points to the relative underperformance of adaptation partnerships. Moreover, there is very little evidence that adaptation partnerships have successfully raised additional funding for adaptation.

We believe *localized* partnership processes could contribute in a more direct manner to adaptation in developing countries. SMEs could play an important role in these processes, for instance, as local producers and suppliers to larger companies. SMEs could also be a crucial actor linking donor countries, multinational corporations and local communities. International and donor organizations, which currently lead most recorded adaptation partnerships, could facilitate the participation of SMEs in localized partnership processes by improving access to (financial) resources, enhancing knowledge about climate change and vulnerability, and raising awareness of the private and public benefits of community-level adaptation.

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Government approaches to catalyse MSME resilience to climate change

Abstract

Governments and public institutions in the Global South play an important role in encouraging and enabling Micro, Small and Medium Enterprises (MSMEs) to be more resilient towards climate change. While corporations are increasingly investing in making their operations more climate-resilient, many MSMEs, especially those in the informal sector, lack the resources to be able to do without a supporting enabling environment.

The public sector should send the right signals and encourage the promotion of new economic opportunities that are resilient to climate change. They should also acknowledge that strategies and actions for resilient development are dependent on clear communication, the involvement of the informal sector and the promotion of long-term sustainable behaviour.

While in many developing countries governments may not have the capacity to provide financial support, they do have the capability to influence the enabling environment through various policy instruments. Prioritizing policies confined to one sector is insufficient, and climate change adaptation and building resilience crosscut other issues of concern. Governments that have integrated adaptation into their development planning across agencies have had far reaching impacts on MSMEs.

Introducing subsidies and tax relief can stimulate MSMEs to reduce their risk through adaptation or engagement in opportunities through innovation, leading to increased profits or making investments more viable. Irrespective of country, it is essential that governments conduct a rigorous assessment of the impacts of policy decisions relating to climate change for both the short and long terms.

1. Introduction

With MSMEs accounting for the majority of businesses in the Global South, it is inevitable that they are and will be affected by climate change. While MSMEs themselves may not be large carbon emitters, they are the most vulnerable of businesses, and efforts to adapt or innovate should be supported by the public sector. In many cases, MSMEs acknowledge the need to be resilient to climate change but are limited by their lack of capacity (Ingirige, Proverbs, & Jones, 2008). Even in cases where the longer term climate change risks are evident, MSMEs are likely to prioritize more immediate risks (Jewitt & Baker, 2012). Consequently, longer term precautionary adaptations and innovations to address the effects of climate change are often challenged by the lack of resources and are thus given a low priority.

Actions taken by MSMEs to increase resilience to climate change need not be drastic; small changes in current activities such as seed selection and basic technology use, for example, can have a significant impact (Dalberg, 2015). Given the lack of resources, the challenge lies in encouraging MSMEs to reprioritizing the 'less threatening' longer term climate change risks and to take action.

For MSMEs to be effectively resilient to climate change, a supportive enabling environment is required. This paper recognizes the need for a collaborative approach from actors across all platforms but focuses on the public sector, specifically national and regional government policies that have been implemented to encourage MSME participation in adaptation.

With their ability to form sound policies and standards, governments can play a crucial role in catalysing MSME resilience to climate change. While many governments have already committed themselves to addressing climate change, the focus has been largely on climate change mitigation (i.e. reducing emissions), with a concentration on the larger companies. In cases where governments have addressed climate change resilience as part of their development strategies, private-sector engagement, in particular by MSMEs, is limited (Dougherty-Choux, Terpstra, Kammila, & Kurukulasuriya, 2015).

This paper explores and analyses methods of resilience used by governments targeting MSME to:

- 1. *adapt* current operations to be more resilient to climate change, or
- 2. *innovate* new products or technologies in order to partake in green technology solutions.

In term of adaptation, this refers to decreasing the vulnerability of MSMEs to negative climate change impacts on their current business activities. The assumption is that climate change is inevitable and that adaptation strategies increase the resilience of existing MSMEs. In addition, in the context of this paper, 'innovation' refers to green technology operations, that is, the acceleration and exploration of renewable energy technologies that allow for climate change adaptation and are climate resilient. Government interventions to encourage innovation may apply to existing MSMEs or allow new businesses to partake in advances in new technologies.

2. Scope and methodology

Acknowledging that further work needs to be done to develop a comprehensive understanding of government policies regarding MSME resilience to climate change, this article aims to identify the existing gaps and contribute to further discussion and research.

While it is acknowledged that the enabling environment is comprised of many elements, this paper looks at government approaches that include incentives (*pull driver*) and disincentives (*push driver*) based on a comprehensive literature review and using specific examples from case studies. It also determines whether the driver has the effect of *adapting* MSME operations to be more resilient to climate change or encouraging MSMEs to *innovate* new products or technologies to partake in green technology solutions.

The case studies in this paper focus on Sub-Saharan Africa and Central and South Asia, whose populations have the greatest dependence on MSMEs (Bacchetta, Jansen, Lennon, & Piermartini 2009). Not only are MSMEs in these areas the main source of employment, income and market access, they also underpin the core structure of most communities, and thus government instruments to increase resilience are particularly important.

3. Government methods for adaptation and innovation

The governments of countries in the Global South have a critical role to play in encouraging MSME resilience to climate change through adaptation and innovation. It is essential that the right signals are sent and that a policy

environment is provided that is conducive to effective MSME engagement. This can be achieved by incentivizing productive actions or removing potential distortions (Fankhauser, 2016). Based on the emerging literature, this article focuses on the following instruments, through which governments have enabled MSME adaptation and innovation for purposes of climate change resilience:

I. Financial and economic policies
II. Regulations
III. National policy
IV. Public sector 'investment'.

In order to achieve an effective government-induced enabling environment for MSME resilience to climate change, a combination of each of the above is required, which should not be implemented in a mutually exclusive manner. The instruments mentioned above differ from Public Private Partnerships (PPP), which are often very complex, large, and require private investments or the setting of prequalification criteria, making it difficult for MSMEs to compete in the market (World Bank, 2017), particularly in the context of developing countries. Commercial models/Public Private Partnerships (or PPPs) are, however, important because they can maximize the strengths and contributions of the public and private sectors in (infrastructure) investment and efficient service delivery, and they are particularly useful in conditions where:

- Governments lack sufficient capital resources for the scale of (water) infrastructure and service needs;
- Greater efficiency in infrastructure provision, operation and maintenance, and service delivery are needed to sustain them;
- Governments face capacity constraints and wish to mobilize additional skills and expertise from the private sector and other non-state actors to deliver key services;
- Greater value creation from public assets is needed.

In general, two forms of commercial models/PPPs are mainly used, namely:

a) Models where private investment is required and responsibility for revenue collection is given to the private-sector partner (which can apply arrangements like lease, franchise, BOT and concessions);

b) Models in which the private-sector partner receives regular payments from the government, which may fund this from user fees, tax revenues or both, and payment to the private-sector partner is based on performance targets set by the government.

The latter form is proving especially important, as it can be applied to a much wider range of infrastructure and (basic) services sectors, such as those where user fees are insufficient to recover costs, where they cannot be charged or collected, where taxation is an appropriate form of financing, and where traditional full-cost recovery for the services provided is culturally or politically difficult.

Regulations and subsidies, including tax relief mechanisms, can be implemented by governments in the form of push and pull drivers. Push drivers refer to voluntary or involuntary instruments whereby a policy or regulation has motivated the MSME to move away from a current activity or operation by creating a deterrent or 'pushing' them to be more resilient. Pull drivers, on the other hand, refer to instruments that are usually left to the MSME to implement, i.e. are voluntary, whereby the government provides an attractive incentive, thus 'pulling' the MSME towards adaptation or encouraging it towards innovation.

Regulations are largely defined in the context of this article as those instruments that have legal force (OECD, 2010). They are the rules and laws implemented by governments, including standards and codes, as well as resource restrictions. Indeed, it can be argued that regulations are a mitigation strategy, as well as an opportunity for innovation, a pull factor to encourage participation in renewable energy technologies.

Subsidies are among instruments that have been used by governments to reduce the costs of adaptation. The types of subsidies include, but are not limited to, utility, research and development and green technology subsidies. These economic and financial incentives have been applied where market inefficiencies have clearly been identified, with targeted subsidies being implemented with the aim of removing the inefficiencies.

Another economic and financial incentive that has been implemented to promote adaptation in resource-constrained sectors has been the use of tax relief. Through targeted tax credits or deductions, MSMEs may be encouraged to invest

in more adaptation strategies. The public sector can also offer tax relief to stimulate research and innovation in green technologies (Ingirige et al., 2008).

Governments can integrate adaptation and innovation into their development planning across multiple agencies in order to conserve resources, improve productivity and strengthen community resilience. National climate strategies allow governments to describe their intentions and actions and create further certainties over regulatory, incentive and disincentive, and public spending policies. Acknowledging that governments may be limited in their financial capacity to commit themselves to significant infrastructure investment, they still have the ability to invest in less financially intensive activities, such as information dissemination, including supporting infrastructure, as well as the training and upskilling of MSME communities.

4. Government instruments assessment

Government approaches to catalyse MSME resilience to climate change have the potential to create a significant positive impact. However, uncoordinated inter-sectoral policies can have an adverse impact by hindering adaptation efforts (European Commission, 2013). The review of the existing literature found that there is a significant gap in policies directly targeting MSMEs. In the majority of cases, MSMEs are indirectly affected through the actions of larger private-sector players who have made efforts to adapt or innovate based on government policies (Pauw, 2014).

A critical challenge faced by MSMEs is that the majority operate in the informal sector. As a result, they are limited in their capacity to adapt or innovate due to their inability to access finance, new market opportunities and public-sector services legally (Crick et al., 2016). The inclusion of the informal sector by policy-makers should therefore be a key consideration in their decision-making.

Policies that relate to adaptation and innovation target different sectors. For adaptation, these are mainly focused on the most vulnerable MSME sectors, such as agriculture, livestock, fisheries and forestry. In contrast, government tools used to encourage innovation in green technology solutions mainly affect businesses in the energy and infrastructure sectors.

4.1 Financial and economic policies

Subsidies have been introduced by governments mainly as a pull driver and have served as a tool for both adaptation and innovation. While subsidies are a short-term option, it is critical that MSMEs do not become dependent on them and to acknowledge that they will be phased out in the longer term (Dougherty-Choux et al., 2015). It is also critical for governments to assess the behavioural implications of certain subsidies. In many countries in the Global South, public utilities such as energy and water are heavily subsidized. While this makes consumption affordable by MSMEs, it also leads to high and wasteful levels of consumption (Clements et al. 2013). However, if these subsidies were reduced or removed without careful consideration, MSMEs may be subjected to negative shocks to their operations. This further emphasises the crucial importance of a supporting enabling environment that encourages adaptation measures. The dilemma for policy-makers lies in creating the right balance between providing incentives for businesses to invest in green technologies (supply side) and creating a market for adaptation by making businesses more climate resilient.

Taking irrigation schemes as an example, this may appear to be an effective solution in reducing farmers' dependence on the weather. Case Study 1 describes the example of the Government of India issuing subsidies for investments in drip irrigation. The result was that businesses found it difficult to become profitable because farmers (assuming they could afford the technology in the first place) had access to subsidized water and were paying lower prices. Therefore, they did not see the benefit of implementing drip irrigation systems. This is an example where adaptation solutions and

Case Study 1

Country: **India**
Sector: **Agriculture**
Driver: **Pull**
Strategy: **Innovation (for suppliers of drip irrigation) & adaptation (for farmers)**

The Government of India heavily subsidised investment in drip irrigation by 50–90%. Despite the subsidy encouraging businesses to enter the sector, many folded due to a combination of: a) the lack of timely payments made by the Government and b) lack of uptake by farmers who were paying very low prices for water and did not see the benefit in purchasing drip irrigation.

(Dougherty-Choux et al. 2015)

Case Study 2

Country: **Philippines**
Sector: **Resources**
Driver: **Push**
Strategy: **Innovation**

The Government of Philippines successfully deregulated its downstream oil sector. Removing subsidies provided on fossil fuel consumption in the form of low, regulated prices or tax levels was implemented throughout the whole product chain, proving removal of subsidies effectively is possible provided it is done in a systemic manner.

(Mumar, 2016)

investments in new technologies are not viable in instances where public utilities are heavily subsidized (IFC and EBRD 2013). While not applicable in all cases, mechanisms such as block-rate pricing for specific actors to access water can still be safeguarded in cases where governments plan to increase prices.

In the case of energy, as consumption increases and climate change threatens current energy sources, it is important for governments to enable behaviour that encourages MSMEs to invest in alternative sources of energy, which will be cheaper in the long run. Gradual increases in electricity prices, for example, can stimulate innovation and investment in green technologies, while also strengthening resilience by MSMEs (Dougherty-Choux et al., 2015). Governments can also redirect the budget for subsidies to programs that help MSMEs and poor communities adapt to climate change. In order for this to be possible, the prices of alternative energy sources must be as competitive as the less environmentally friendly fossil fuel-based options.

In terms of tax breaks, many developing countries have large informal sectors and weak tax collection systems. In these cases, implementing tax breaks would not benefit MSMEs, which mainly operate outside of the formal sector (Dougherty-Choux et al. 2015).

Just as subsidies can be implemented to attract MSMEs to behave in a certain way, the removal of subsidies can be used as a push factor. Case Study 2 shows that subsidies can in fact be removed successfully, as long as the chain effect is considered and a plan is implemented with a long-term perspective. According to the IMF (2013), the success of the reform can be attributed to its comprehensiveness. Rather than ad hoc price adjustments or the simple introduction of an automatic pricing mechanism, deeper reforms were implemented throughout the whole product chain.

Case Study 3 illustrates a successful adaptation story made possible largely because of actor engagement across the value chain. In Zimbabwe, an MSME adapted to climate change by reducing its dependence on producing beer from drought-prone crops. This required a combination of:

- a) the willingness of farmers (in agreement with the brewer) to grow the more drought-resistant grain as opposed to the traditional grains
- b) The availability of red sorghum seeds at affordable prices by farmers
- c) information dissemination to maximize yield potential
- d) appropriate infrastructure for the commodity to reach the market.

With the right government mechanisms (subsidy on inputs such as fertilisers and seeds), information dissemination and market creation (brewery willing to purchase the sorghum), this not only supports climate change adaptation by the brewery, it also enables farmers to be more resilient to climate change. Just as the production of climate resistant crops is essential for adaptation, the existence of a market is also essential. Government interventions addressing fragments of the value chain are therefore not sufficient: an effective enabling environment requires the entire value chain to be supported.

4.2 Regulations

Regulations have traditionally been used as a push driver to promote more environmentally friendly practices (e.g.

Case Study 3

Country: **Zimbabwe**
Sector: **Agriculture**
Driver: **Pull**
Strategy: **Adaptation**

A beer-brewing company played its part in adaptation, with respect to red sorghum farming. The brewery produced beer with small grains such as red sorghum, which are more climate resilient than the crops typically grown in the region. As a result, red sorghum production has grown considerably.

(Dougherty-Choux et al. 2015)

Case Study 4

Country: **Tajikistan**
Sector: **Agriculture / Retail**
Driver: **Pull**
Strategy: **Adaptation**

The simplification of certification and labelling process for agro-biodiversity-friendly products immediately allowed for a greater participation by MSMEs, in agro-processing businesses and farmers due to the greater demand for the good.

(United Nations, 2012)

stopping the use of coal). While mitigation policies are not addressed in this article, there is still an indirect flow-on effect from such regulations, including encouraging businesses to focus on innovative and climate-resilient technology solutions.

However, regulations can also act as a positive pull driver for MSMEs to engage in adaptation, as illustrated by Case Study 4. In Tajikistan, the simplification of certification and labelling requirements immediately allowed MSMEs to take advantage of this regulatory 'relaxation' and create market opportunities.

Land is a particularly important topic to address in respect of regulation. Studies in Ghana show that farmers without clear land rights are less confident in adapting to new crop technologies and less willing to take risks for purposes of long-term adaptation (McDermott, Castells-Quintana, & Del Pilar Lopez-Uribe, 2015). Governments should therefore consider appropriate land reforms that establish or strengthen property rights as the key to adaptation.

Case Study 5

Country: **Namibia**
Sector: **Resources**
Driver: **Pull**
Strategy: **Innovation**

More than a third of the drinking water supplying Namibia's capital, Windhoek, is sourced from water reclamation plants. Namibia is a leader in reaching clean water standards, which was made possible with appropriate regulations for water safety standards, combined with municipal by-laws for water saving. As a result, extreme water shortages can be overcome even in times of severe droughts.

(Lahnsteiner & Lempert, 2007)

In addition, land-use regulations, even if they are intended to promote more resilient crop varieties, can hinder adaptation. Under such circumstances, regulations to plant certain crop types without consideration of their suitability to the environment may not be optimal, resulting in severe losses in the long term (Lewandrowski & Brazee, 1993). Despite the good intention to comply, the costs of such regulatory compliance without financial and social infrastructure support in the value chain can be costly. MSMEs often lack the resources and access to make the transition (GIZ, 2012).

In terms of innovation, as illustrated in Case Study 5, the standards and codes relating to water recycling and the requirement to implement water-saving measures provided a platform for companies to become involved in a resource-effective solution. Due to advances in water-recycling technology, Namibia is setting a global example by increasing its resilience to climate change by making adequate water resources available. Given the prospect of increased water scarcity due to climate change, the shift to 'renewable energy as opposed to fossil fuel power (enabled by government support) could be the difference between frequent blackouts and reliable energy access, while continuing to ensure the availability of adequate resources' (Rogers, 2012).

4.3 National policy

Just as the absence of incentives can limit MSME involvement, the absence of national policies can limit regional government involvement. The presence of national policies allows the government's priorities and intentions to be communicated to the public, providing momentum to regional governments in their own policy planning. Without a clear national policy, there can be uncertainty over the legal and regulatory implications, as well as regarding investment incentives (Dougherty-Choux et al., 2015). It should be recognised, however, that in themselves national policies are not sufficient without the involvement of regional governments, agencies and other actors to implement the desired interventions.

Regional governments have considerable power to develop and implement their own policies relevant to adaptation and innovation *specific* to their region. Decentralized policies concerning land, raw materials and basic infrastructure should be specific to the regional and local circumstances.

Case Study 6

Country: **Kenya**
Sector: **Cross-sector**
Driver: **Pull & push**
Strategy: **Adaptation (Innovation to lesser extent)**

The Kenyan government developed specific national climate change policies, strategies and action plans. Further, the launch of the National Climate Change Response Strategy implemented a participatory approach involving all levels of government with clear action plans.

(Crick et al. 2016)

Moreover, integrated planning across ministries allowing for 'adaptation plans that conserve resources, improve productivity, and strengthen the resilience of communities' (Fjose, Grünfeld, & Green 2010) is important. Furthermore, public officials can have more direct and effective contact with MSMEs at the municipal and district levels.

As outlined in Case Study 6, the Government of Kenya launched the National Climate Change Response Strategy (NCCRS). In doing so it followed a participatory process, bringing together national and regional governments, as well as private, development and civil-sector actors (Crick et al., 2016). Through the NCCRS, the government was able to 'kick start' regional government interventions directed at climate change adaptation and innovation in communities, including MSMEs. Furthermore, the national government has continued to commit to climate change resilience through its Intended Nationally Determined Contribution, which 'identifies key priority adaptation actions, including (…) creating an enabling environment for the resilience of private sector investment (…) and enhancing the resilience of the agriculture, livestock and fisheries value chains by promoting climate smart agriculture and livestock development' (Crick et al., 2016).

As sector policies are largely implemented by regional or specific government agencies, an integrated national climate strategy allows the implementation of policies to increase the resilience of MSMEs to climate change to be accelerated.

Case Study 7

Country: **Zimbabwe**
Sector: **Agriculture**
Driver: **Pull**
Strategy: **Adaptation**

The Zimbabwean Environmental Management Agency, a government body, installed eight weather stations and developed a customized rainfall forecasting system. The access to weather information resulted in a reduction of harvest loss and also allowed for planning for future crop planting.

(UNDP, 2016)

4.4 Public-sector investment

Public-sector investment is an essential enabling environment tool that governments can use to allow MSMEs to innovate and adapt to climate change. It is recognized that many governments in the Global South may not have the capacity to provide significant infrastructure investment support. However, they do have the capacity to implement a wide variety of investments, such as facilitating information dissemination to remote areas, prioritizing green technology research and development, and investing in training and education. While public-sector investments may not be climate-specific, without them, climate change adaptation and innovation would not be possible.

As many of the MSMEs operating in the Global South are in rural areas, access to timely climate information is a valued asset (Collier, Conway, & Venables, 2008). This is particularly applicable for those in the agricultural and livestock sectors, where the effects of climate change have a direct impact on their business, as highlighted in Case Study 7.

In enabling MSMEs to be climate-resilient, it is essential that there is access to and integration into national and international markets (OECD, 2004). Public-sector investment goes beyond significant infrastructure-driven capital investments. Many communities in both rural and urban areas suffer from a lack of skills and capacities. Better targeting of support and training services would play a vital role in promoting and enabling adaptation measures already in place.

In Case Study 8, MSMEs were able to increase their resilience to climate change by replacing their crops with more climate-resilient varieties. This would not have been possible without investment in procurement, promotion, training and support by the Zimbabwean Environmental Management Agency, district governments and local agencies. Another example of public-sector investment

Case Study 8

Country: **Zimbabwe**
Sector: **Agriculture**
Driver: **Pull**
Strategy: **Adaptation**

Public sector led procurement, promotion and training of climate resistant crops considerably increased the resilience to drought and flooding.

Local government structures were also important, including district council and local-level leadership. The cooperation of the government ensured a sense of country ownership of the intervention.

without significant capital expenditure being required can be found in Cambodia, where the Cambodian Agricultural Research and Development Institute, a government institution, was able to develop a new stream of a rice seed variety capable of withstanding harsh weather conditions (UNDP, 2012). Public-sector prioritization and support for research and development in MSME adaptation and innovation is in itself an investment contributing to the resilience of MSMEs.

MSMEs need to gain greater access to data and information tailored to their needs and scales of operation, as well as to innovations and new technologies. The ability of MSMEs to respond to climate change challenges is hindered by their inability to forecast and act according to weather changes. Information dissemination also goes beyond weather forecasts. In many MSME communities, awareness of government policies and incentives is limited. Therefore, closer integration between governments and MSMEs is strongly recommended to ensure a greater take up of the adaptation and innovation instruments available to them.

Engagement with communities with a heavy reliance on MSMEs for their livelihoods and vice versa (i.e. MSME communities), while not being a policy in itself, is critical to building adaptive practices. Further, studies from Sri Lanka, South Africa and Vietnam show that MSMEs, especially female-led MSMEs, are concerned with cultivating positive community relationships (World Resources Institute, 2015).

4.5 Overview of case studies

Each of the case studies presented in this paper have their own uniqueness and incorporate specific instruments enabling MSME resilience to climate change differently. As

Table 1.

Case Study	Instrument	Driver	Strategy	Successful (Y/N)	Reason for success/failure
1	Financial & economic policies	Pull	Innovation	N	Water was already cheap, with no incentive to move to drip irrigation
2	Financial & economic policies	Push	Innovation	Y	Involved systemic removal
3	Financial & economic policies	Pull	Adaptation	Y	Actor engagement across the value chain
4	Regulations	Pull	Adaptation	Y	Allowed for greater participation by MSMEs
5	Regulations	Pull	Innovation	Y	Appropriate regulations and by-laws implementing the development of green technologies
6	National policy	Pull & push	Adaptation	Y	Involved a participatory process, with all levels of government having a clear action plan
7	Public sector investment	Pull	Adaptation	Y	Access to information allowed for planning for future crop planting
8	Public sector investment	Pull	Adaptation	Y	Investment in procurement, promotion and training, in addition to multi-level stakeholder engagement

illustrated in the Table 1, the majority of instruments are focused on adaptation rather than innovation.

In cases where innovation was the strategy used, MSMEs were not the primary stakeholders driving these technologies, due to their size and resource constraints. Thus, it was found that innovation strategies are more suited to larger players, as the capacity for MSME participation is limited.

5. Conclusion

Government approaches to catalysing MSME resilience to climate change requires dedicated measures to be put in place through policy incentives and disincentives. An effective enabling environment incorporating MSMEs should be a government priority in developing national climate strategies and public-sector investment.

Of the case studies analysed, including the eight included in this article, the majority were found to focus on climate change adaptation, with only a few concentrating on policies supporting the development of new products and/or green technology solutions. The latter were mainly an indirect result of push drivers relating to climate mitigation strategies, where the government, by discouraging a certain activity, has 'pushed' MSMEs to consider new approaches in the form of green technologies.

In cases where the successful implementation of instruments has produced MSME resilience to climate change, there was a clear pattern of a pull driver, such as financial incentives, combined with adaptation involving a multi-stakeholder participatory approach. This participatory approach extends to government operations: it is important to consider whole value-chain initiatives and to establish an integrated national and regional government approach using multi-sector agencies. A national climate change policy can facilitate this, but it only provides a foundation of the work to come in the future. Government interventions should always be considered in the form of a participatory, long-term approach that is inclusive of MSMEs, particularly those in rural areas.

One of the fundamental reasons why MSMEs are so vulnerable to climate change is that their operations lie outside the formal sector. This limits their access to services, including finance and insurance facilities. In rural areas, even those that are in the formal sector are limited in their financial capacity and technical resources to access affordable financial products. With this in mind, incentives and disincentives such as subsidies and tax breaks will not be effective in creating climate-resilient MSMEs without the inclusion of the informal and rural sectors or without promoting long-term sustainable behaviour.

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SECTION C

Improving access to climate data and decision-support tools tailored to MSMEs

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Cambio Score: quantifying climate-change impacts for MSMEs in developing countries

Abstract

Climate change threatens to affect all countries across the world. Country-specific challenges from climate change depend on a vast array of factors and thus demand customized decisions at scale from public-sector policy-makers. However, judging the impact of such measures will be incomplete without considering the role of private-sector entities, which has gone largely under-investigated. In this chapter we focus on the impact of climate change on micro, small and medium-size enterprises (MSMEs), which constitute about 80% of the private sector in developing countries. We present and demonstrate the Cambio Score, an open-source, data-driven framework to help policy-makers and private-sector entities identify country-specific threats from climate change. Longitudinal data from multiple country-specific macro-scale indicators provides quantitative evidence of vulnerability to these disruptions, as well as of countries' respective readiness to leverage funding and investment to introduce adaptive measures. Our framework, the Cambio Score, is intended to be used as a data-driven decision-making tool for policymakers, MSMEs and researchers alike. We demonstrate its usefulness through a case study of a medical supply MSME in Bangladesh, where our framework has been able to identify and prioritize areas of vulnerability and means of readiness in the face of climate change.

1. Introduction

Climate change adaptation is a pressing concern facing humanity, representing a call to action for public- and private-sector entities to respond to these new risks, challenges and opportunities. Significant efforts in this direction have been undertaken for the public sector to create policy-level change (Parry, 2009). However, private-sector analogues of such efforts are sparse and limited to large corporate entities, mostly in the developed world (Ihlen, 2009; Seville & Gannon, 2015). These innovative corporations are not representative of the state of the global private sector, as the majority of the population in the developing world relies on micro, small and medium-size enterprises (MSMEs) for their livelihoods (Kushnir, Mirmulstein & Ramalho, 2010). Indeed, MSMEs account for nearly two-thirds of total employment in developing and developed countries alike (Auboin et al., 2016) and 45% of their respective GDPs (Ayyagari, Beck & Demirguc-Kunt, 2007). An important challenge faced by the private sector is the lack of quantitative information to guide adaptation strategies (Frey et al., 2015). The survey by Ihlen (Ihlen, 2009) identifies the following key challenges in creating adaptation strategies aimed at engaging MSMEs:

- MSMEs have limited resources and information compared to public-sector organizations and large corporations. The limited nature of this information is compounded by the lack of incentives for private-sector organizations to be transparent in their strategic efforts.
- Adaptation strategies need to be specific to the MSME's country, business sector and practices. This limits the utility of a one-strategy-fits-all model for enterprises in a country.

1.1 Our Solution: the Cambio Score

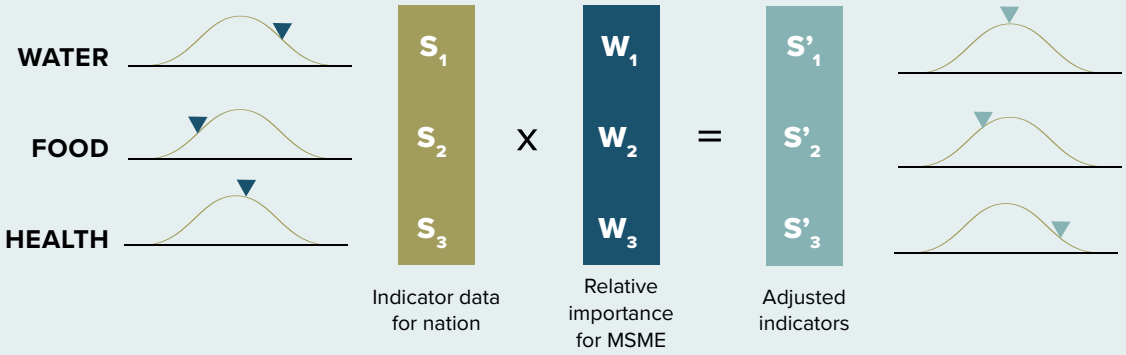
In direct response to these challenges, we propose the 'Cambio Score', a custom measure with which to quantify the climate change readiness and vulnerability of a given MSME. The Cambio Score is intended to be open-source and customizable. The use of open-source and publicly available data in our approach democratizes access to the collected data and information for MSME stakeholders. Its bespoke nature permits insights that can be tailored to an enterprise's own business priorities. This analysis makes it possible for an enterprise to identify and prioritize climate change risks to its business in a tangible fashion. Since this framework is intended to help MSMEs in developing countries faced with climate change impacts, we call it the 'Cambio Score'.

The Cambio Score is a private-sector version of a public-sector conceptual framework called ND-GAIN (University of Notre Dame Global Adaptation Index Country Index) (Chen et al., 2015). The ND-GAIN Score quantifies climate change impacts for public policy-makers, and its conceptual framework directs adaptation strategies. In this chapter we discuss how the ND-GAIN framework is used to provide the same level of insights for MSMEs. The Cambio Score is not being actively used by MSMEs at the time of writing this paper, but it is our hope that its appeal to MSMEs, public policymakers and larger corporations will make it a viable candidate for driving adaptation strategies, especially in developing nations. Since the Cambio Score is open-source and relies on publicly available data, MSMEs can evaluate their vulnerabilities and readiness without expensive internal research. Public authorities can also use sector-specific insights from the Cambio Score for their country to create and guide climate change policies to suit the need to MSMEs. Similarly, large corporations can use the Cambio Score to evaluate and reinforce the resilience of individual MSMEs in their value chains. The following features of the Cambio Score make it a particularly viable research and decision-making tool for MSMEs:

- **Democratized Access to Data**. Structured efforts and frameworks in the public sector have democratized access to a wealth of openly available research data on climate change and its impacts. In computing the Cambio Score, we fuse a variety of openly available indicators collected primarily by the World Bank (World Bank, 2016a) and the Food and Agriculture Organization of the United Nations, Statistics Division (FAOSTAT, 2016). These datasets are considered top reference resources for companies informing them of adaptation strategies due to their consistency of data collection and organization across all countries within the study (Frey et al., 2015).

- **Bespoke Insights**. While customized adaptation strategies exist at the country level in the form of National Adaptation Plans (NAPs), finer-grained equivalents for enterprises within these nations are conspicuously absent. Through the Cambio Score, we achieve exactly this: viewing national indicator data in terms of how they affect MSMEs and their business models. In doing so, we make it possible to suggest equivalents to the National

Figure 1. Transforming ND-GAIN into the Cambio Score.



The indicators on the left indicate the relative importance of climate change factors to Bangladesh as a country overall. When these country values are re-weighted according to the MSME's priorities, we obtain an adjusted score which reflects climate change readiness and vulnerabilities as they pertain to the MSME in the given country. In this example, the ND-GAIN framework suggests that water-related factors should be the top priority for Bangladesh to tackle. When viewed through the eyes of our example of an MSME medical supplier, the adjusted score gives health-related factors a higher priority. In this way, we merge raw indicator scores for a country (i.e. $\{s_1; s_2; s_3\}$ for Bangladesh) with the MSME's priorities $\{w_1;w_2;w_3\}$ to give us a composite picture of how climate change factors are impacting on a given business in a given country.

Adaptation Plans for MSMEs. Consider a fictitious medical supplier MSME in Bangladesh: even though the National Adaptation Plan for Bangladesh may have very few specific provisions for medical suppliers, the Cambio Score steps in as a useful proxy specific to the medical supply industry and directs its adaptation efforts.

1.2 Cambio Score: pivoting ND-GAIN to the private sector

As mentioned above, the Cambio Score is grounded in the conceptual framework of the ND-GAIN Score. We start with the same national-level indicator data as we did in ND-GAIN score and we re-prioritize their relative importance in terms of a given enterprise. This additional re-weighting is designed to augment the ND-GAIN framework with the enterprise's priorities. As a result, we now have a framework which is both open-source and individualized to an MSME in a given country. Devising an adaptation strategy from the Cambio Score is similar to doing so from the ND-GAIN approach, albeit using re-weighted indicator data. Since the Cambio Score is intended for the private sector, the resulting insights should be expected to differ potentially from those of the country concerned in general.

We illustrate this transformation using a simplified version of one of our case studies in Section 5. For clarity in this example, we restrict ourselves to a small subset of publicly available ND-GAIN indicators for water, food and health for 192 United Nations member nations for 2014. We then compare how Bangladesh ranks in terms of each of these indicator values globally in terms of their percentile values.[1] Bangladesh has an extremely high vulnerability from water-related factors (96%ile), a low risk of food-related factors (7%ile) and near upper quartiles of risk due to health-related factors (69%ile). This would imply that adaptation efforts should be directed towards mitigating water-related vulnerabilities above all else. Viewing these in the context of a hypothetical MSME distributing medical supplies in Bangladesh, we find that these scores need to be re-prioritized. The MSME then takes the Corporate Adaptation Survey[2] and finds the relative weights of these

[1] If a country's indicator has a percentile value of 'X', it means that 'X%' of the countries in the dataset have a value less than the given countries' indicator value. e.g. when we say Bangladesh's vulnerability to water-related climate change is in the 96th percentile, it means that 96% of the nations in the dataset had a lower vulnerability to water indicators

[2] The University of Notre Dame Global Adaptation Index (ND-GAIN) and Four Twenty Seven, with support from BSR (Business for Social Responsibility), created the 2015 Corporate Adaptation Survey. This survey captures the interplay between 37 businesses and climate change: https://news.nd.edu/assets/164209/2015_corporate_adaptation_survey.pdf

three indicators as they pertain to its business model. This heterogeneous weight distribution helps contextualize national risks for the enterprise. In our mock example, we arrive at an expected insight for the MSME and mathematically validate it using the Cambio Score approach. In contrast, being agnostic regarding the MSME's priorities would have led us to pursue an entirely different avenue of adaptation efforts which are not aligned with the enterprise's priorities. This approach is summarized visually in Figure 1.

Since the Cambio Score relies heavily on the ND-GAIN framework, we first introduce its internal structure, including data collection, index computation and, most importantly, how it can be used to generate data-driven interpretable strategies for public policy-makers. We then demonstrate how this framework can be generalized for private-sector adaptation efforts. For MSMEs to be able to replicate this analysis for their internal assessments, we provide example case studies of MSMEs in developing countries. We conclude with notes on future research directions that our framework makes possible.

2. Related work

Climate change research has been the focus of many organizations across disciplines. In this section, we restrict ourselves to the immediately relevant works that help contextualize our decision-engine.

Niemeijer and DeGroot have set out guidelines for using indicator data to solve environmental policy problems (Niemeijer & DeGroot, 2008), which we use in this chapter. Hinkel noted the need to bridge the gap between 'science' and 'policy', thus paving the way for the enablers we use in this chapter (Hinkel, 2011). The Intergovernmental Panel on Climate Change (IPCC) publishes Assessment Reports on Climate Change, of which Working Group 2 relates to 'Impacts, Adaptation, and Vulnerability' (Mach & Mastrandrea, 2014). These reports are crucial in respect of our definitions of the relevant terms and help guide the enablers and indicators. Vulnerability-based assessments like that used by Eriksen and Kelly (Eriksen & Kelly, 2007) involve a deep analysis, but do not consider readiness components. Nelson et al. (Nelson, Adger & Brown, 2007) apply a purely technical perturbation-based model for environmental change. Fussel (Fussel, 2010) illustrates how inequalities between countries lead to inequalities in the impacts from climate change. Biesbroek et al. (2010) evaluate climate change strategies for European countries, showing that these studies can be performed for a subset of nations as well. Contemporary assessment solutions like the CEO Water Mandate, the WRI Aqueduct Global Flood Analyzer and the WRI Aqueduct Water Risk Atlas focus largely on water-related stressors of climate change. The SDG Framework considers water, greenhouse gases, power systems and investment factors.

In contrast, the ND-GAIN and Cambio frameworks encompass a more comprehensive array of indicators through their conceptual enablers. Hammitt et al. (1992) and Lempert (2003) recognize the policy decision-making potential of data and provide insights into how useful strategies can be drawn up using hints from the data.

3. ND-GAIN Score: quantifying climate change at the country level

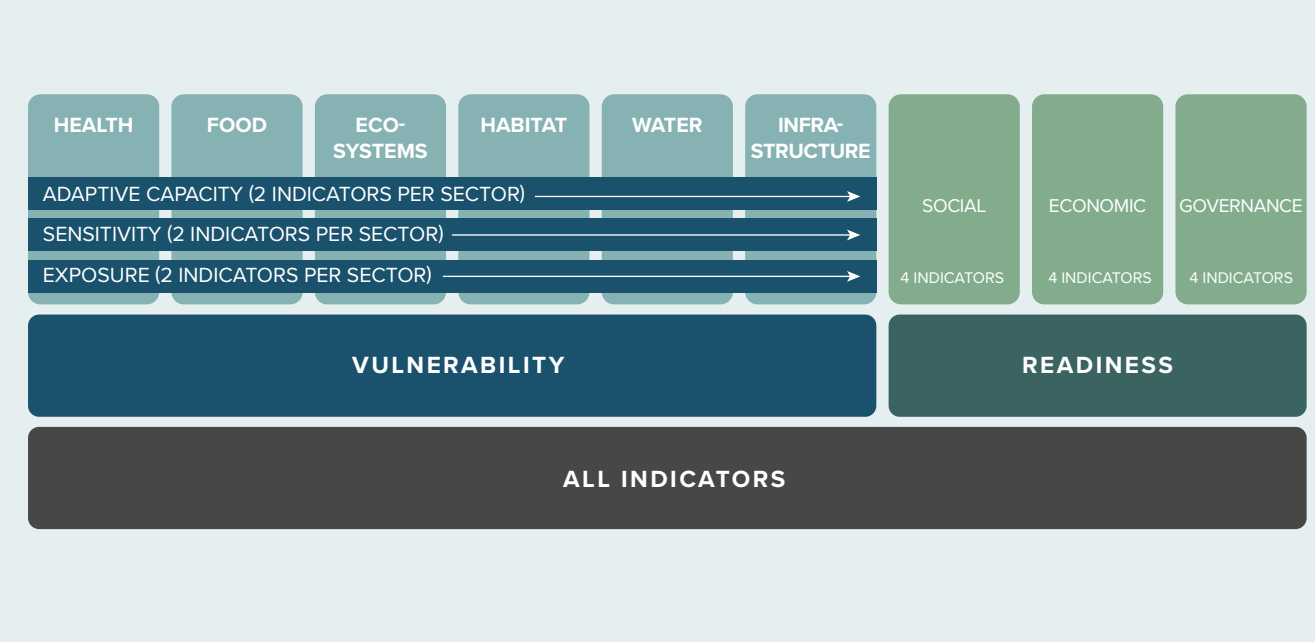
The far-reaching consequences of climate change impacts make it exceedingly difficult to quantify the associated risks and levels of preparedness. For example, climate change adaptation efforts in Vietnam's Xuan Thuy district have been shown to depend on socio-economic conditions caused by the privatization of mangroves (Adger, 1999). The resultant poverty has affected human habitat adversely and placed the wider population at greater risk of climate change-related hazards. Other studies show how extreme changes in maize yields in Africa and Latin America may cause large-scale shifts in arable land and thus in human population by 2055 (Jones & Thornton, 2003). This is shown to impact negatively and disproportionately on the economies of maize-growing countries like Chile, Argentina, Brazil and Mexico.

These seemingly diverse avenues of impact require a structured approach to direct adaptation efforts. The underlying challenges can be categorized as *conceptual* ('What needs to be quantified? What is an agreeable definition of said phenomena?') and *technical* ('What is the best way to quantify these phenomena?'). Using these goals as our guide, we designed the ND-GAIN score to quantify climate change impacts as comprehensively as possible.

3.1 Conceptual and Technical Enablers

Assessments in various areas like climate change vulnerability, the readiness to absorb foreign investments or a country's ability to adapt are extremely varied in their individual perspectives. The UNFCCC structures these assessment efforts internationally and has been instrumental in arriving at a common understanding of

Figure 2. **An overview of all the indicators chosen in the framework**



them. This falls into the category of a conceptual enabler, providing much needed consensus across institutions. With conceptual enablers in place, the technical aspects of climate change assessment are now the focus of research. A lack of quality data, opacity in practices and the diverse nature of assessment methodologies all represent open problems in climate change research. We cover the data-acquisition and data-quality problems in Section 3 in greater detail. Since these assessments directly affect state policies and guide international investments, the urgency and magnitude of the impact of technical enablers become greater than ever.

A number of solutions have been proposed to address the sector-specific quantification of climate change impacts (Section 2), thus setting the stage for a more comprehensive cross-sector approach: the ND-GAIN Score. In computing this score, we combine the impact of climate change across a large range of sectors both internationally and longitudinally. These indicators and their definitions are largely derived from UNFCCC guidelines. As a result, we provide a conceptual structure and identify indicators affected by climate change. This is outlined visually in Figure 2, where we present a conceptual schema of which indicators pertinent to climate change have been considered, and how their hierarchy is structured within the ND-GAIN conceptual framework. On a technical level, we quantify the risk and readiness of each nation to guide policy-makers. As a result of fulfilling both the conceptual and technical enabler requirements, the ND-GAIN Score provides a decision framework for countries to implement their National Adaptation Plans (NAPs).

At its core, the ND-GAIN score is a climate change assessment aggregation framework. We express two distinct conceptual components of these assessments: the *vulnerability* and *readiness* of a specific country with respect to climate change. We then discuss how we collect the data from publicly available resources, including notes on preprocessing and data-cleaning for reasons of the reproducibility of results. We express the ND-GAIN score as a function of these quantified measures of readiness and vulnerability, showing how the visual depiction of their matrixes can be interpreted.

3.2 Conceptual framework: vulnerability and readiness

The general guidelines followed in selecting the data for ND-GAIN are conceptually similar to those set out by the UNFCCC:

Table 1. Full list of vulnerability indicators used in proposed framework. These are broken down into their respective exposure, sensitivity and adaptive components.

Sector	Exposure	Sensitivity	Adaptive Capacity
Food	• Projected change of cereal yields • Projected population change	• Food import dependency • Rural Population	• Agriculture Capacity (Fertilizer, Irrigation, Pesticide , Tractor use) • Child Malnutrition
Water	• Projected change of annual runoff • Projected change of annual groundwater recharge	• Fresh water withdrawal rate • Water dependency ratio	• Access to reliable drinking water • Dam capacity
Health	• Projected change of deaths from climate change induced diseases • Projected change of length of transmission season of vectorborne diseases	• Slum population • Dependency on external resource for health services	• Medical staff (physicians, nurses and midwives) • Access to improved sanitation facilities
Ecosystem Services	• Projected change of biome distribution • Projected change of marine biodiversity	• Dependency on natural capital • Ecological footprint	• Protected biomes • Engagement in International environmental conventions
Human Habitat	• Projected change of warm period • Projected change of flood hazard	• Urban concentration • Age dependency ratio	• Quality of trade and transport-related infrastructure • Paved roads
Infrastructure	• Projected change of hydropower generation capacity • Projection of Sea Level Rise impacts	• Dependency on imported energy • Population living under 5m above sea level	• Electricity access • Disaster Preparedness

- **Relevance**. Data sources which measure the human well-being aspects of climate change were considered relevant to ND-GAIN. These indicators range from the biophysical impact of climate change to socioeconomic factors that may amplify or mitigate its impacts.
- **Provenance and Reliability**. The data need to be collected and/or curated by authoritative organizations. Sources include programs run by country governments, bilateral or multilateral aid agencies, international organizations, NGOs, private investors, etc.
- **Coverage**: In order to track changing trajectories, indicator data should be available for various points in time. For the scope of the analysis to be truly global, data need to be available for a large proportion of United Nations member states.
- **Transparency and Interpretability**. Indicator data need to be publicly available for them to have transparency. The ND-GAIN framework uses these indicator values directly in its recommendations, making it important for these indicators to be readily interpretable.
- **Actionability**. Indicators need to be tied to actionable arms of governments, the private sector or communities.

By means of these guidelines, we identify two major families of variables: those pertaining to vulnerability and readiness. These are explained in detail below and are contextualized in Figure 2.

Vulnerability is defined by the Intergovernmental Panel on Climate Change as "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2014). The ND-GAIN framework interprets the IPCC definition to decompose vulnerability into the following cross components (Chen et al., 2015), which we bring over to the Cambio Score in this chapter:

Table 2. Full list of readiness indicators used in proposed framework.

Component	Indicators			
Economic Readiness	• Doing Business Indicators			
Governance Readiness	• Political Stability and non-violence	• Control of Corruption	• Rule of Law	• Regulatory Quality
Social Readiness	• Social Inequality	• ICT infrastructure	• Education	• Innovation

- **Exposure**. The climate stress faced by the country. This is mostly represented by the biophysical impacts of climate change, regardless of socioeconomic context.
- **Sensitivity**: The extent to which a country is responsive to climate exposure. The country's dependence on sectors that are exposed to climate risks and the proportion of population at risk to a climate change hazard are factored into sensitivity.
- **Adaptive capacity**. The availability of social resources to implement adaptation and thus reduce exposure and sensitivity.

Readiness is a country's ability to apply (or absorb) economic investments for adaptation actions. For readiness, we consider the following cross-components:

- Economic readiness: the readiness of a country's business environment to leverage investment for adaptation purposes in the form of creating and maintaining enterprises.
- Governance readiness: the institutional factors that enhance the application of investments for adaptation purposes.
- Social readiness: factors in public society that enhance the application of investments to adaptation purposes.

Contribution. This conceptual framework unifies a number of vastly different climate change factors which can be categorized under vulnerability and readiness. Enterprises, especially MSMEs, can now use this framework, instead of using their limited resources to create their own adaptation conceptual frameworks.

3.3 Technical framework: data scraping

In accordance with the provenance and reliability requirement listed above, we queried a wide variety of publicly available sources curated by authoritative organizations. A full list of sources for Tables 1 and 2 is available in the Appendix. Prominent data sources include the Food and Agriculture Organization of the United Nations, Statistics Division (FAOSTAT), and the World Bank Database (World Bank, 2016a; World Bank Group, 2016b).

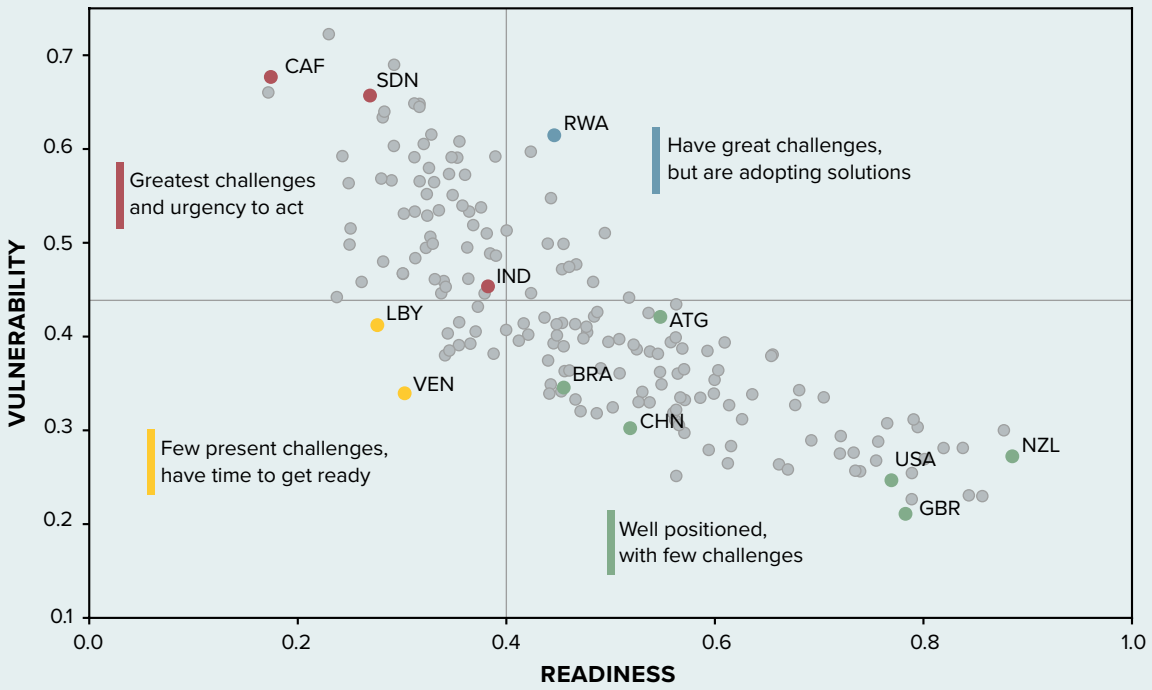
The greatest challenge here is the extremely fragmented nature of data sources. These sources are available in extremely diverse forms, ranging from sources that can be queried to structured tabulated spreadsheets to tables embedded in academic research. Various data-quality concerns still remain after acquiring the raw data from these sources. Sources differ in terms of various metadata attributes, including, but not limited to, number of years covered, number of countries covered, frequency of updating, spatial granularity and percentage of missing values. We attribute the vast majority of these missing values to data-collection procedures. The summary statistics of the missing values are summarized in Subsection 7.2 (Appendix).

Contribution. By providing a methodology to fuse extremely diverse sources of data together reliably, this framework makes it possible to implement the conceptual ideas set out by the ND-GAIN framework. Even if data have been carefully curated at their source, addressing modalities, coverage and the other data-quality concerns voiced in this chapter represents an area open for research.

3.4 Computing the score

The result of these preprocessing steps is that we combine about 80 raw signal indicators into 45 indicators that are used to compute the ND-GAIN score. A detailed description of each indicator and the fusion process is covered in Chen et al., 2015. For each vulnerability sector (health, food,

Figure 3. Interpreting the vulnerability and readiness quadrants.



For a given year, we plot each country's vulnerability against its readiness. Each point represents the country for which these indices have been computed. This shows us rough divisions among the 192 nations displayed in this figure, ranging from those that have the fewest climate change threats and are best situated to tackle them to those that face the greatest threats from climate change and are ill-equipped to adapt to it.

etc.), the arithmetic mean of all its constituent indicators is computed. A similar mean is calculated for the readiness sectors. The final ND-GAIN Score is a composite of these vulnerability and readiness scores.

$$ND - GAIN\ Score\ = (Readiness - Vulnerability + 1) \times 50$$

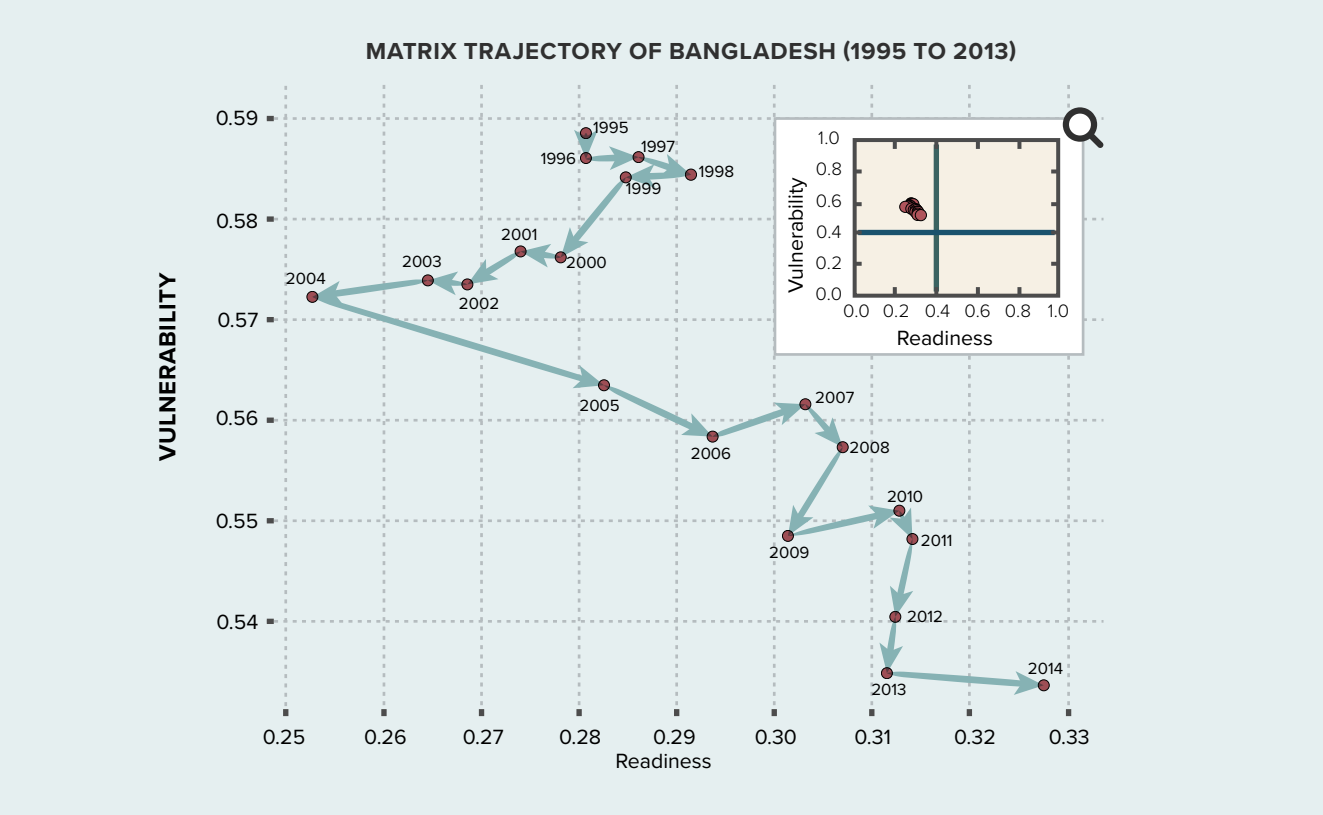
A higher ND-GAIN score indicates that the country concerned is better equipped to adapt to climate change. For ease of reference, the ND-GAIN score is measured on a scale of 0 to 100, which is made possible by the shift by +1 and multiplication by a factor of 50. A step-wise account of this calculation is available in Chen et al., 2015.

3.5 Interpreting the vulnerability-readiness matrix

A quick visual aid in evaluating countries' respective vulnerability and readiness figures simultaneously is to plot them on a two-dimensional plane against each other. Figure 3 shows how plotting vulnerability and readiness for multiple countries against one another enables a direct visual comparison. The plane itself can be divided into four quadrants, divided by the vulnerability and readiness thresholds. The median values of all the vulnerability and readiness scores across time can be used as such a threshold. This divides the countries into roughly equal-size quadrants, each of which is explained in Figure 3. These divisions are useful for quickly contextualizing the values for a given country compared to a global average.

Tracking the vulnerability and readiness of a given country across the years results in trajectories similar to those shown in Figure 4. Here, we can identify the overall trends in a country's vulnerability and readiness over time and track where its climate change adaptability is going along both axes. We revisit both concepts when interpreting the Cambio Score in Section 5.

Figure 4. A vulnerability–readiness trajectory of Bangladesh over the years 1995 to 2013



4. The Cambio Score

The ND-GAIN Framework attributes equal importance to each of its 45 indicators. However, enterprises operating within a particular industrial sector perceive climate change as a heterogeneous threat. Using surveyed responses from these enterprises, we mimic this perceived heterogeneity using multiplicative weights to adjust the component indicator values. For example, if an enterprise relies heavily on ICT infrastructure, we ascribe a higher weight to the infrastructure component. Mathematically, we represent the original scores as $\{s_i\}$ and the weights as $\{w_i\}$, giving us adjusted scores of $s_i' = w_i \times s_i, \forall i$. Since we do not need to alter the ultimate values of vulnerability and readiness, we also ensure that $\sum w_i = 1$ [3].

Quantifying priorities as weights. Using the surveyed inputs of the MSME, we arrive at ranked weights as follows. An MSME ranks its priority areas in the form of the ordered set (r1, r2,..., rn), where $r_i \in \{1, \ldots, n\}$. Given the above constraints, each weight is simply a scaled version of its rank. Mathematically, we can express this as

$$w_i = (n - r_i)\frac{2}{n(n+1)}$$

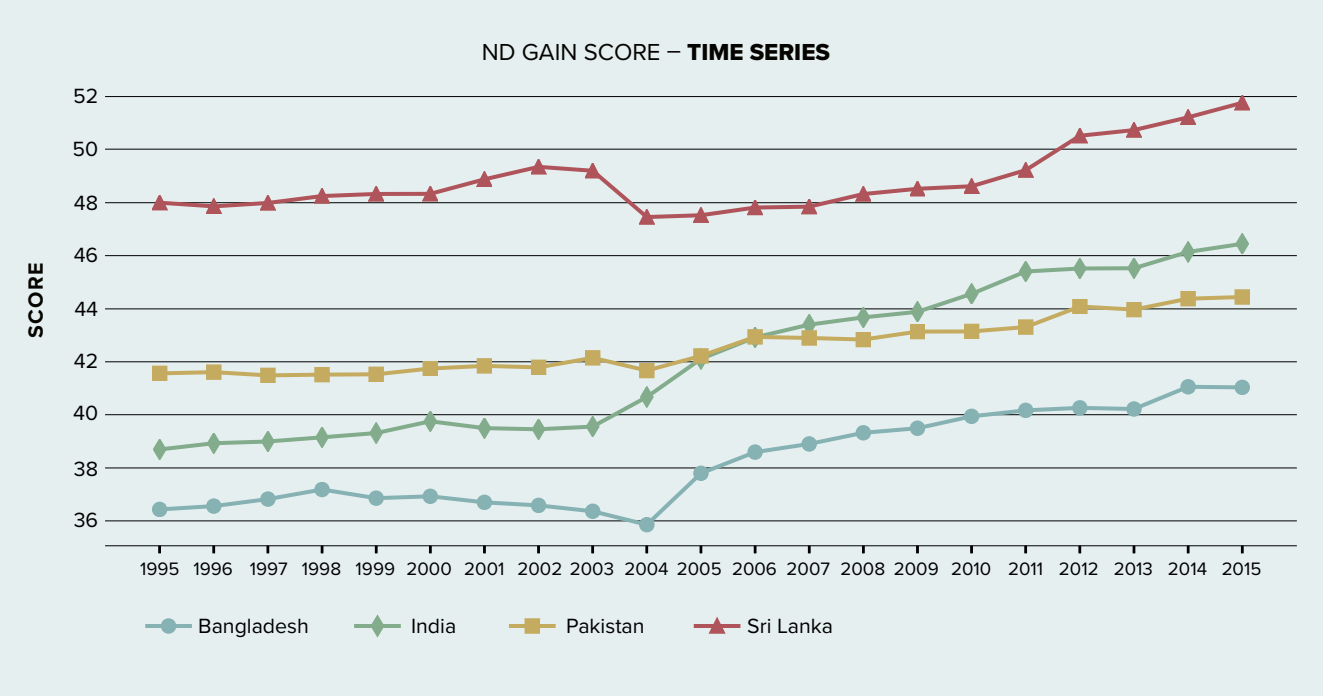
where the scaling factor is simply the sum of all possible ranks. Using this expression, we assign a higher weight to a higher ranking indicator (low value of r_i). In future research, this surveyed ranking can be replaced by constant sum inputs.

The end-result of this step is that each sector's score is re-weighted according to the MSME's priorities, resulting in counterparts of its original ND-GAIN values. For example, if a health sector score for a country is 0.55 and it aligns highly with an MSME so that its weight is 1.5, its re-weighted value (which we denote by 'Health') would be 0.825. We repeat this process at all levels of indicators shown in Figure 2, and obtain vulnerability' and readiness' values as counterparts of their ND-GAIN versions.

Computing and interpreting the Cambio Score. The Cambio Score's readiness and vulnerability values are meant

[3] It should be noted that, where w_i=1, $\forall$ i, i.e. when each factor is considered equally important, this technique is the same as computing the ND-GAIN Score.

Figure 5. A time-series plot of the ND-GAIN score for Bangladesh



to be the identical to the corresponding ND-GAIN values. We simply tweak the underlying weights for each indicator using wi derived above. This means that the computation of the Cambio Score is exactly the same as that of the ND-GAIN Score, as shown below. Note how we use readiness' and vulnerability' (the re-weighted counterparts) instead of the ND-GAIN readiness and vulnerability to keep the structure of the Cambio Score similar to that of the ND-GAIN Score.

$$Cambio\ Score\ = (Readiness' - Vulnerability' + 1) \times 50$$

In the Cambio Score, it is the adjusted scores that are the focus rather than the overall aggregate score. The nuance imparted by the MSME's priorities is used as a complementary signal to the indicator data.

Contribution. The Cambio Score builds upon the ND-GAIN framework by merging MSME priorities into an otherwise agnostic metric. While the ND-GAIN framework identifies which climate change factors one must consider and where to source data for them, the Cambio Score framework addresses how much relative importance an MSME should place on each of these factors.

5. Using the ND-GAIN and Cambio Score: Case study and insights

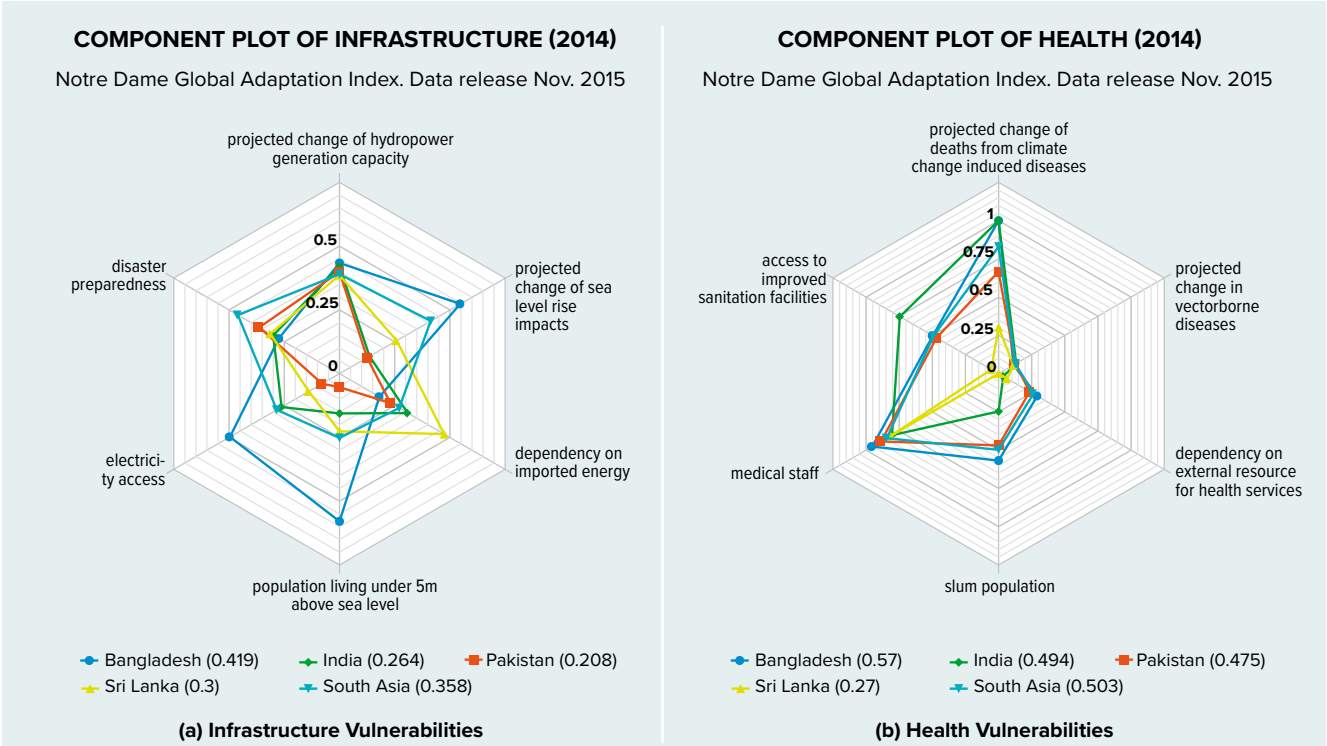
Having computed the ND-GAIN Score and the Cambio Score, we illustrate their respective deployable use-cases for Bangladesh and one of its medical supplier MSMEs. These use-cases and their generated insights highlight the prioritization of their intended users, ND-GAIN being useful for decision-makers in the public sector, and Cambio Score benefiting the private sector.

Case study

The data used in this case study come from the publicly available ND-GAIN data spanning a twenty-year period from 1995 to 2014 and containing indicators for 192 United Nations member states. The longitudinal nature of the data makes it possible to perform time-series analyses on it. Each of these analyses for a particular country can be contextualized relative to any of the other countries or regions, making it possible to monitor relative progress along climate change objectives.

We have selected Bangladesh for our case study, since it is a developing nation with an extremely high reliance on MSMEs. Bangladesh's MSMEs constitute 99% of its private-

Figure 6. Key vulnerability sectors for Bangladesh.



The ND-GAIN framework suggests that Bangladesh should prioritize its infrastructural vulnerabilities. This changes are viewed through the lens of a medical supplier MSME in Bangladesh, where health vulnerabilities play a large role in its climate change adaptation strategy.

sector industrial establishments and employ 70-80% of its non-agricultural labor force (Alauddin & Chowdhury, 2015). First, we consider Bangladesh at the national level and analyze its ND-GAIN score to identify public policy areas that it must concentrate on. We then apply the same analysis to the example of the medical supplier MSME from Figure 1 and use its Cambio Score to identify priority areas for the enterprise. By displaying the two analyses side by side, we highlight the differences in the identified priority areas, while the underlying methodology remains relatively unchanged.

Vulnerability vs readiness trends. Figure 4 shows that Bangladesh's readiness has seen a steady uptrend since 2004. Its vulnerability score has largely dropped throughout this observation period, barring 2006 and 2009. We investigate the possible causes of this in later subsections.

Comparison with neighboring countries. Figure 5 shows that Bangladesh's ND-GAIN score weakened until 2004 but has since picked up, which seems to be in line with the trend observed in the region. Bangladesh has a disproportionately high vulnerability from its infrastructure (population living under 5m above sea level and projected impacts from changes in sea level) and food (projected changes to cereal yields, population density and child malnutrition), as can be seen from Figure 6a. Despite this, its Ease of Doing Business indicator (Jayasuriya, 2011), at 0.405, is comparable to India's and better than Pakistan's. This is validated by the fact that Bangladesh has successfully attracted various internal and external investors to help bolster its resilience and contribute to its national development.

Suggestions for policy-makers. Figure 6a shows that Bangladesh's main vulnerability areas are a combination of rising sea levels, compounded by its rising population. These findings are in agreement with multiple independent studies throughout the years (Ali, 1999; Karim & Miramura, 2008; Roy, 2009). Building infrastructure to mitigate the impact of natural disasters remains a priority area, as observed by Roy (2009). The development of agricultural practices which are resilient to adverse climate events and produce higher

Table 3. Adjusted Cambio Score values for medical MSME in Bangladesh.

Here we tabulate various sectors of climate change vulnerability and their ND-GAIN scores. We then see how the MSME's importance rankings of these sectors adjust these scores. Here, we use a proportional inverse rank to transform the ND-GAIN score into the Cambio Score values (a higher rank means a lower weight). According to the ND-GAIN framework, Bangladesh should prioritize combating vulnerability from water-related factors. However, for our sample MSME, the Cambio Score shows that the priority area should be health-related vulnerability.

Vulnerability Sector	Ranking	ND-GAIN score (s_i)	Cambio Adjusted (s'_i)	w_i
Health	1	0.5886	1.0090	1.7143
Food	2	0.5512	0.7874	1.4286
Water	3	0.6001	0.6858	1.1429
Human Habitat	4	0.4724	0.4049	0.8571
Infrastructure	5	0.2953	0.1687	0.5714
Ecosystem Services	6	0.5309	0.1517	0.2857

yields is essential if Bangladesh is to leverage its natural resources to feed its population. Bangladesh is also ripe for economically sustainable innovative and entrepreneurial initiatives, which will serve to empower and adapt the nation to be better prepared for climate change.

Salient insights

Consider the medical supplier MSME in Bangladesh from our earlier example. In addition to the ND-GAIN indicator data, we also have access to the MSME's business priorities. Say our example MSME ranks the sectors of vulnerability in order of importance as shown in Table 3: this affects the relative weights of the indicators as perceived by the MSME. The shift according to the importance of these indicators is evident from Table 3 and pictorially from Figure 7, where the adjusted Cambio Scores for the health and food vulnerabilities surpass those for the water-related vulnerabilities. At the other extreme, ecosystem services are a relatively much lower priority for this MSME, so its contribution is extremely low (0.08) towards the Cambio Score, even though its ND-GAIN Score contribution was relatively high (0.52). This is clearly indicative of how much of an immediate risk climate change-related health factors pose to this MSME.

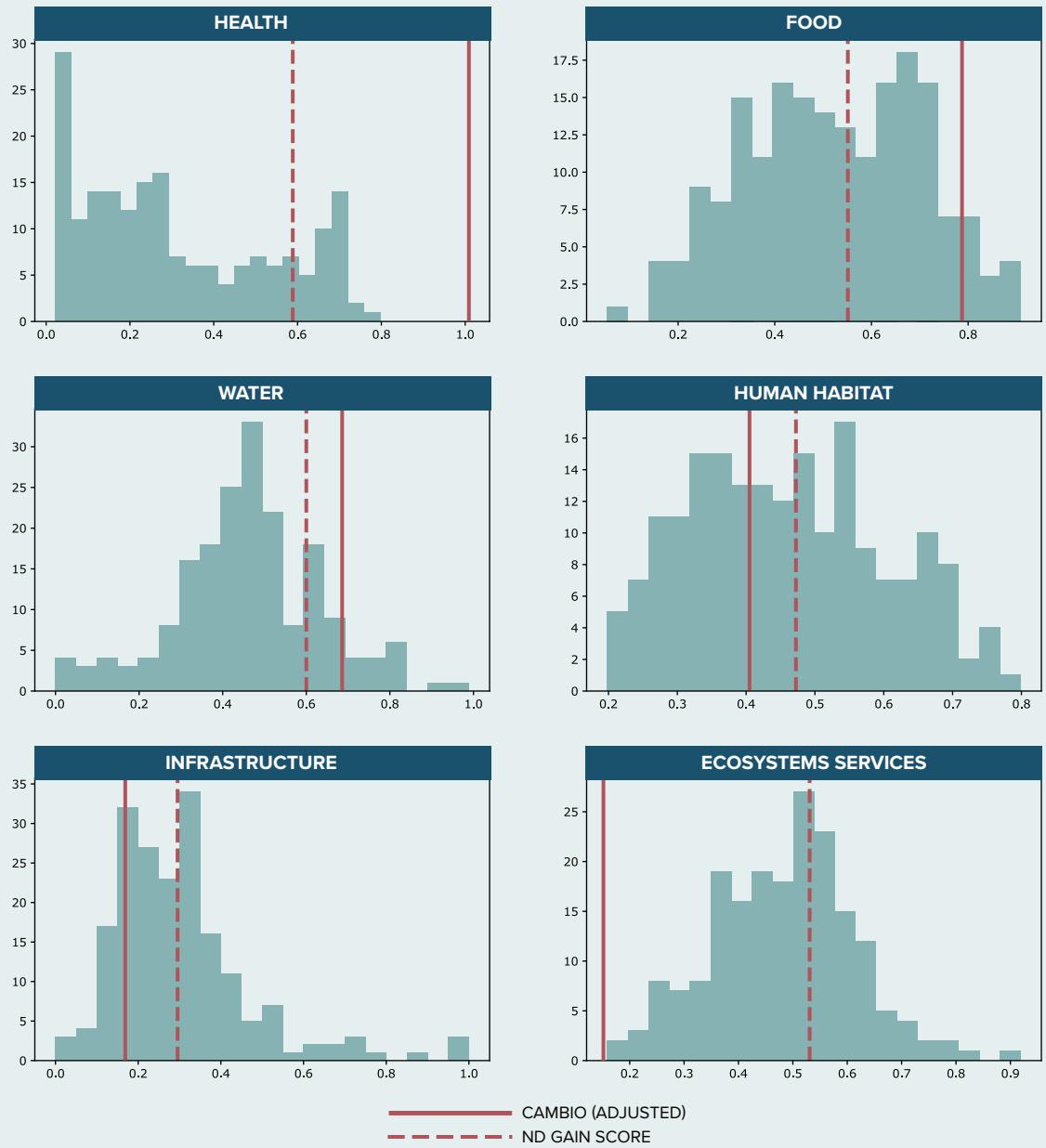
Cambio Score Assessment. A nuanced look at health vulnerabilities for South Asian nations in Figure 6b reveals that Bangladesh is not very different from India and Pakistan. However, the extremely high absolute values of Projected Deaths from Climate Change Induced Diseases, combined with the priorities identified by the MSME, make it an important avenue of adaptation efforts.

Suggestions for the MSME. The most pressing concern for our sample MSME is that of climate change-induced diseases. In our example of an MSME medical supplier, this component represents an opportunity for projected demand and strategic growth. From a business perspective, the MSME should then invest heavily in medical supplies that help treat these diseases. Another avenue of improvement for this and other such MSMEs would then become to incentivize employee health care and preventative care against these diseases. This minimizes the risk of the MSME losing employee productivity to disease, which would be compounded by its already small size. For the MSME, this threat supersedes reinforcing its supply chain against rising sea levels. This is an example of how the Cambio Score can be used to inform business strategy for a given country and MSME.

6. Conclusion

While nations all over the world are recognizing the threat posed by climate change and implementing adaptation policies under the guidance of the UNFCCC, private-sector engagement has been extremely sparse and resource-constrained. Within this sector, MSMEs employ a majority of the population worldwide and contribute significantly towards global GDPs. Throughout this chapter we have proposed and demonstrated a framework to engage and

Figure 7. Cambio Score vs raw indicator values.



Broken lines indicate the original indicator values, solid lines the values adjusted by Cambio Score. These are contextualized by the overall global distribution of the respective vulnerability sectors.

empower MSMEs with the ability to devise their own plans for climate change adaptation.

Our framework represents a step towards quantifying the highly subjective topic of climate change adaptation. This is the first open-source, transparent and actionable framework to combine both conceptual and technical enablers into adaptation strategies. The Cambio Score builds upon the conceptual foundation of the ND-GAIN Score (Chen et al., 2015) and identifies various components of climate change readiness and vulnerability for the country its target MSMEs are in. Using the ND-GAIN framework's strengths, we amalgamate extremely diverse and openly available indicators for 192 nations. This involves a

significant technical component of preprocessing the data, cleaning them and then computing the index value. The ND-GAIN Score imparts equal importance to each climate change sector, given that its intended users are public-sector stakeholders. The Cambio Score pivots this measure away from creating National Adaptation Plans (NAPs) to making adaptation plans for MSMEs. Structurally, both scores are designed to fit on a scale of 0 to 100, where a score of 100 implies the greatest amount of readiness and least amount of vulnerability.

The potential for MSMEs to identify their vulnerabilities and degrees of readiness in the face of climate change risks and to participate actively in adaptation efforts can effect the global-scale impact. By design, the Cambio Score is open-source[4] and bespoke, making it appeal to MSME adoption on both fronts. With the Cambio Score being open-source and free to implement, MSMEs do not have a cost-based entry barrier to creating their own adaptation risk assessments and strategies. The only requirement for end-users of this tool is the presence of an internal self-evaluation of business priorities. We recognize that the necessary skills to compute the Cambio Score evaluation may not be present within an MSME and therefore recommend that local governments and stakeholders in the MSME step in to create this assessment for them. Since these organizations are often responsible for multiple MSMEs within a country, this transfer of technical responsibility facilitates consistency of analyses across the entire portfolio of enterprises. Since MSMEs can assign business priorities in all of the sectors covered by the Cambio Score, the resulting insights are tailored to both the MSME and the country it operates within. By means of our case study, we show a reproducible assessment methodology for both the ND-GAIN and Cambio Scores, the insights of which cater to public- and private-sector decision-makers respectively.

We can also identify the following avenues of future work based on building the Cambio Score framework. The theoretical structure set out by the Cambio Score would benefit from real-world case studies of MSMEs. Such case studies would begin with the identification of several at-risk target MSME business sectors in developing nations that have high ND-GAIN vulnerability and low readiness scores. Then, initial surveys of MSMEs would determine how their priorities differ from nation-wide priorities. An ideal combination for such a real-world study would be an MSME sector whose priorities differ drastically from its national priorities. Using the Cambio Score, researchers could then evaluate the best strategies to help that MSME sector formulate an adaptation strategy. Impact studies of the country's adaptation strategy, compared to that advised by the Cambio Score, would then serve to effectively decouple and highlight the effects of using the Cambio Score. In the most ideal scenario, we would see the country benefiting from the ND-GAIN approach, while the specific MSME sector would draw its benefits from the adaptation strategy suggested by the Cambio Score. Another avenue of research would be to automate the decisions suggested by the Cambio Score. Since these decisions are derived from multivariable indicator data, researchers and policy-makers could formalize the task of navigating towards a reduced risk of climate change as an optimization in multi-dimensional space. Real-world indicators are subject to multiple practical limiting factors, which can then be incorporated as constraints in the multi-dimensional optimization process. For example, to go from Cambio Score *CS1* to *CS2*, a given country can only advance its 'education' readiness by two percent a year, making it impractical to suggest a target overall growth of ten percent in education over two years. This is where the policy-aware constrained model would step in and provide a more grounded trajectory for researchers. Following the same example, say the sample country could only achieve a two-percent growth in education, but can boost its ease of doing business indicators to compensate for this, then we can still achieve the same Cambio Score goal of *CS2*. Ultimately, the goal of the Cambio Score can only be achieved through global dissemination and ease of use for MSME decision-makers. Further market research into MSME adoption of the Cambio Score will ultimately lead to the greatest level of impact from adaptation efforts.

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[4] The front-end of the ND GAIN Score tool can be accessed at http://index.nd-gain.org:8080/index_main.py?tool_type=basic. MSME stakeholders can use this front-end to obtain the component-wise ND GAIN score and then reweight it towards the enterprise's requirements.

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7. Appendix

7.1 Deliberate Exclusions in Data

Notable deliberate exclusions from our study include gross domestic product and the impact of climate-related disasters and exposure measures. Even though GDP per capita is very commonly used in indicators, adding this indicator would doubly penalize developing countries, so we chose to drop it from our framework. Climate-related disasters are not an actionable variable. However, we note that disaster data would be a good external signal for decision-making and validation. Exposure measures are driven by biophysical factors and are only actionable through abatements of greenhouse gases.

7.2 Preprocessing and Data Cleaning

Given the incomplete and extremely variable quality of these raw data sources, we apply several preprocessing steps before arriving at the ND-GAIN score:

- Aggregation. For indicators like agriculture capacity, we use an aggregate of multiple available measures. Aggregated, these indicators compensate for each other's missing values and account for where irrigation or fertilizer use is less necessary because of rainfall or good quality soils.
- Aggregating GIS data GIS-based indicators like projected change of sea level rise impacts [29] and projected change of marine biodiversity [30] are collected at half-degree grid intervals on a projection of the earth's surface. To use these as country-level indicators, we aggregate them for grids lying inside the geographical boundaries of the respective countries.
- Thresholding outliers. To mitigate the e ect of outliers, their values in several indicators have been thresholded appropriately.
- Impute Missing Values. In order to aggregate indicator data, we need to impute the missing instances. The scope of the imputed values is purely restricted to computing the ND-GAIN score.
- Scaling. Once the missing data have been imputed, indicator data are scaled to lie within the 0 to 1 range. For indicators like medical staff, this needs to be scaled such that a low score is mapped onto a score of 1, since it is in the vulnerability category. Conversely, for readiness indicators, a higher scaled value is better.

Photo credit: Caroline Schaer

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Climate information for climate change adaptation

Abstract

In developing countries, micro, small and medium enterprises (MSMEs) employ a large proportion of the working population and make a significant contributions to GDP. As such, they have a potentially large role in strengthening a country's resilience to climate change. However, few national meteorological and hydrological services (NMHSs) in developing countries, especially in Africa, provide weather and climate information products tailor-made to the needs of MSMEs. This paper outlines a number of challenges that NMHSs face in creating weather and climate information (WCI) products and services for MSMEs, as well as a number of private initiatives that have proved successful. Furthermore, the need for public-private partnerships is identified as a pragmatic way to enhance the NMHSs capacity to provide MSMEs with the WCI products they require. Only when MSMEs have access to timely, accurate, usable and useful WCI can their capacities to adapt be unlocked.

1. Introduction

Especially in developing countries, the impact of climate change and climate variability on the economy is significant. However, limited access to resources, combined with a lack of human resource and technological capacity and other challenges that developing countries face, limit their adaptive capacity and resilience to climate change. With MSMEs in low-income countries contributing more than 60% to GDP and employing over 70% of the working population (Keskin et al., 2010; Dalberg, 2011), MSMEs can play a significant role in enhancing the adaptive capacity of developing countries. This paper focuses on that role, as well as on the potential for weather and climate information (WCI) products to support MSMEs. Policy frameworks conducive to private-sector engagement are also discussed, and guidance for the development of tailored information products aimed at the needs of MSMEs in the agricultural sector in developing countries is provided.

The potential benefits of WCI are well documented and are critical for adaptation to climate change. Although slow onset hazards, such as droughts, can have far-reaching and long-lasting impacts, accurate climate information products and services can be used to adapt to and mitigate the effects of such hazards. Early warnings of storms and floods are fundamental for saving lives; accurate agrometeorological forecasts are increasingly important for farmers as traditional weather patterns become less predictable; and reliable weather and climate observations are a pre-requisite for, e.g., index-based crop insurance programs, where insurance payouts to farmers are based on pre-determined indices such as rainfall levels. Early warning systems and climate information can be very effective in reducing losses and achieving productivity gains, largely justifying the costs of the hardware and communication they require. In addition, the social and economic benefits of good weather systems have been well documented. These benefits are primarily realized through early warning systems and reductions in lost lives and assets due to hydrometeorological disasters. But in addition to these benefits, society can benefit in many other ways from the availability of accurate and timely WCI products. Index insurance programs have also been shown to provide substantial economic benefits to small farmers in so far as they facilitate the extension of credit and enhance the level of investment into inputs, resulting in productivity gains, since farmers are covered against weather risks.

The development of WCI products targeted at the needs of MSMEs is the key to unlocking these additional benefits. It is also a huge challenge. The typical technology- and science-oriented NMHS does not speak the same language as the typical MSME. Bridging this gap requires either close collaboration between the NMHS and the private sector or new intermediaries like private-sector spin-offs from the NMHS with a focus on turning information into products. Furthermore, a variety of legal and practical obstacles must be overcome before NMHSs can effectively engage with the private sector.

Despite these difficulties, such efforts are essential to ensure that climate information can be mainstreamed into decision-making processes at both the national and MSME levels and that the additional benefits of investments in WCI systems are realized for the sake of the general public. This is critical for the majority of developing countries with high exposure to climate risks (e.g. Philippines, Guatemala, many countries in Africa). Accurate and timely WCI products, developed for and targeted at the entire agricultural value chain, are thus crucial in helping these countries adapt to climate change and in ensuring that agricultural production systems can meet the increasing demand for agricultural produce in the future.

2. Costs and benefits of investments in wci systems

According to Hallegatte (2012), the main benefits from investments in WCI systems are achieved through the use of early warning systems, which can lead to a statistical reduction in the number of lives lost to natural disasters (Andersson & Treich, 2013; Ashenfelter, 2006; Miller, 2000; Viscusi & Aldy, 2003), as well as a reduction in asset losses. In addition to these benefits, accurate, timely and actionable WCI products provided to the private sector, the public and the government can help increase the benefits from investments in WCI systems by an additional 6-10% (Hallegatte, 2012). Considering that benefit-to-cost ratios of investments in WCI systems in developing countries commonly range from 2:1 to as high as 36:1 (Hallegatte, 2012; WMO, 2015), these potential additional benefits are considerable. There is no one best approach to mainstreaming WCI into MSME's decision-making processes, but nevertheless there is a growing awareness by the governments of developing countries that effective weather and climate systems are a prerequisite for efforts to strengthen their resilience to climate change.

However, a number of important caveats should be added to most cost–benefit assessments of investments in WCI systems. The investments have to be appropriate and must target outcomes that are relevant to the types of hydrometeorological challenges a country faces. The NMHS needs to be willing to invest in product development and quality control and assurance. Furthermore, the country has to commit resources and manpower to maintain equipment and train staff if systems are to be sustainable. Investments in inappropriate technologies, or without long-term budgetary commitments to training and maintenance, will not produce the desired benefits. For example, the acquisition of a Doppler radar, a sophisticated device with high upfront costs and maintenance requirements, in a country that is primarily affected by drought will have limited benefits. Investments in, for example, less expensive satellite-based drought monitoring will have much greater benefits. Consequently, to maximize the potential additional benefits of investments in WCI products, a review of the priorities of traditional NMHSs in developing countries is necessary. And even in cases where radar networks are the ideal observation platform, without the necessary budgetary support, the NMHS will not have the funds or capacities to maintain them, and the equipment will fall into disrepair.

3. Growth in private delivery of wci services

For business owners, there are immediate benefits to climate-proofing their businesses, as is already reflected in the growing demand for WCI services. This growing demand is aimed at MSMEs, especially in the agricultural sector, and is attracting an increasing number of private WCI providers, including civil-society organizations and for-profit companies. Examples are aWhere Weather, Earth Networks, UBIMET, TAHMO, Ignitia, Kukua, Human Networks International (HNI) and MeteoGroup with the Weather Philippines Foundation, to name but a few. Interest in this field as a growth business is further reflected in the recent acquisitions of the Weather Company by IBM and the Climate Corporation by Monsanto. All these companies are addressing some of the diverse needs within the private sector for weather and climate information. Their existence is driven by the inability of many NMHSs to provide the information products required to serve this increasing demand for weather and climate services.

Some of these companies bring together publicly available data and information products and offer them in a user-friendly, easily accessible format. Others create forecasts and other value-added WCI products independently. Among the latter, several install their own equipment on the ground to feed their forecasting systems with additional data in order to improve the accuracy of their forecasts. Some companies only install weather stations to provide, for example, agrometeorological information products or to provide insurance companies with the kinds of data needed for crop insurance products. Then there are companies that focus on the timely and targeted dissemination of WCI products.

All these companies have identified gaps in the market for weather and climate services that the traditional NMHSs are unable or unwilling to fill. Most NMHSs identify their core functions as the collection of hydrometeorological datasets, their responsibility as custodian of these datasets and their responsibilities to fulfill international obligations, for example, towards the World Meteorological Organization (WMO) or the International Civil Aviation Organization (ICAO). At the same time, the creation of relevant WCI products, – that is, relevant to the public or the private sector – and their dissemination is often neglected. These priorities are reflected in the choice of the types of observation network that are being run by NMHSs. The data requirements for climatology or inputs for global circulation models are very different from the data requirements for high-resolution, location-specific, short-term agrometeorological forecasts.

4. Models and challenges for the delivery of weather services

An overview of several private initiatives and the WCI products they provide (or the part of the WCI chain they address) that have demonstrated success will be presented in this section. This is followed by a discussion on the types of observation networks that are best suited to satisfying the data requirements for these products. Several models of transformative change to traditional NMHSs are discussed, ranging from advisory and training services to the outsourcing of substantial parts of the WCI chain.

The outcomes of many willingness-to-pay studies are surrounded by a healthy dose of skepticism, where favorable replies given during interviews do not always turn out to be accurate when push comes to shove. Especially in smallholder farming, several follow-up studies have shown that the initial willingness-to-pay for information services is found to be unrepresentative when the marketing of information products starts (RMSI, 2013; BASIX, Weather Risk and MicroEnsure, 2013). However, and perhaps

due to changing climate patterns that make traditional weather predictions more prone to error, or perhaps due to improvements in educational levels, experience has shown that in many developing countries, smallholder farmers have become more willing to pay for WCI services (Ministry of Food and Agriculture and GIZ, 2014).

In many countries, the changes required for NMHSs to become more market-oriented will require a revision of the legal framework. Compared to most other government institutions, NMHSs, with their large observation networks and computing requirements, are relatively expensive. This often results in insufficient budgets to perform routine maintenance tasks on time or to provide training for personnel. Greater independence achieved by, for example, the transition from a government department or directorate to a semi-autonomous agency or authority provides the management of NMHSs with greater leeway and the flexibility to prioritize, to become more flexible in the way budgets are spent and to become market-oriented. The latter especially is instrumental in providing relevant WCI products and services. In many developing countries, this re-orientation will require significant institutional change. But it is only through the provision of relevant, accurate and timely WCI products, that correspond to the needs of the private sector and the public, that such information can be mainstreamed into decision-making processes at all levels of society. And this mainstreaming of CWI is a prerequisite for effective and inclusive adaptation to climate change.

5. Demand for WCI products

Many, if not all, sectors of a country's economy are affected by weather and/or climate. The often very local scale at which most MSMEs operate makes these enterprises extra vulnerable. Large multinationals, which operate at much larger spatial scales, are much less sensitive to localized extreme weather events, as the effect on their business of extreme weather events at local scales is watered down by the lack of this impact in most areas in which the company operates. MSMEs do not have this advantage. The weather and climate impacts might be very direct, for example, in the case of a farmer's crop being destroyed by drought, or less direct, as in the case of weather-induced changes to consumer preferences. However, all of these impacts have one thing in common. With advance knowledge of a weather event or climate anomaly, actions can be taken to profit from the positive effects, adapt to the expected impacts and/or mitigate the impact of negative effects.

Climate change is already impacting vulnerable areas, leading to more extreme events and changing traditional weather patterns. The latter especially will significantly impact traditional farmers, who rely primarily on indigenous knowledge, as seasons start to change and the indigenous knowledge becomes less and less appropriate. This will consequently affect the entire agricultural value chain in those areas. With increases in population numbers and areas of farming land decreasing, the demand for agricultural output will only continue to increase. To allow farmers to account for a changing climate, they will require timely and accurate WCI products on which to base their decisions.

There are a number of challenges to the efficient and timely delivery of tailor-made weather and climate information products. First of all, traditional NMHSs in most developing countries tend to be scientifically oriented organizations, and their human resources reflect this. Few, if any, of the NMHSs' staff have expertise in fields other than meteorology or hydrology. Most information products that are currently being produced are either very technical and difficult to interpret by laymen, or they are oversimplified, not location-specific enough and/or too generalized to be of real use to professional users. The bright side for NMHSs, especially for those who are modernizing their observation infrastructure and forecasting systems, is that modern forecasting software packages yield a wealth of information. With these outputs, tailor-made information products can be created that correspond very well to user needs. This amount of information far exceeds the requirements of what the NMHS is typically required to provide to the public as a public good. However, the inability to create these information products mostly results from the lack of market-oriented product development and the associated product maintenance, quality control and assurance, as well as the ability to incorporate user feedback into product development in a structured and routine manner. The aim should be to develop a dynamic product that continues to correspond to evolving MSME user needs, which, in addition, are as varied as the MSME landscape. Primary production processes might be disrupted for some MSMEs, while for others the supply chain is affected. Demand may vary depending on weather conditions, or the self-life of stockpile or finished product might be affected. Specific WCI products can be created to suit each of these specific needs. The difficulties involved in NMHS staff translating industry-specific user needs is complicated further by the lack of awareness on the part of MSME owners regarding the

type of information products the NMHS could potentially provide them with. This means that NMHSs must proactively engage each sector in in-depth discussions, so that both sides (NMHS and MSME) can explore the possibilities and work towards designing an information product.

6. WCI products

One interesting example of a tailor-made WCI product can be found in professional horticulture. Greenhouse horticulture in the Netherlands is technologically highly advanced. Climate control computers regulate temperature, humidity, radiation, airflow and CO_2 levels inside the greenhouses in order to create an optimal growing climate. The ability to anticipate weather events such as rain showers accurately is an important aspect of optimizing the greenhouse climate. For that specific purpose, near real-time information on the location, speed and direction of shower systems, drawn from an Application Programming Interface (API) made available by a private weather company, is fed directly into the climate control computers. Based on this real-time information, greenhouse vents and windows are closed just in time for the rain and are opened again once the rain has passed. This system helps optimize production inside the greenhouse and results in a significant increase in yields compared to a traditional rain gauge-based system, whereby, depending on the location of the gauge, rain might fall on the crops (which incurs a higher risk of diseases), or the greenhouses remain shut for too long, resulting in less than optimal growing conditions.

In East Africa and South America, greenhouse horticulture has expanded hugely over the past fifteen years. Farms are usually a lot larger than those found in the Netherlands, and although the level of technology is not quite as high, many technologies, such as the climate control computer, have made their way to these countries. Just like in the Netherlands, growers can save on fungicide use and increase their productivity if accurate and timely information on rain is available. Especially in the tropics, where the tools to regulate greenhouse climates are more limited than in the Netherlands (e.g. no heating, no lighting, no CO_2 fertilization), and rain events are usually more intense and localized, this type of information could be even more important than for Dutch greenhouse farmers. However, in most cases the required type of information, real-time location-specific rainfall nowcasts and ways of making it available to the climate control computer are simply absent in these countries. Although admittedly the very expensive radar systems that are used in the Netherlands might be too expensive to acquire and maintain by NMHSs in developing countries, there are less costly alternatives (e.g. lightning detection systems) that serve practically the same purpose. Since this technology will result in a direct increase in profit, whether through an increase in yields or a reduction in costs (e.g. a reduction in the number of fungicide applications) or both, most greenhouse farmers will, in all likelihood, be interested in paying for the appropriate WCI service.

This is a very specific example, with potentially significant economic benefits, albeit for a relatively small number of MSMEs. However, it illustrates a point of broader applicability: reliable, real-time weather information is of high value to farmers of all crops. Nieveen & Bouma is a company that specializes in the provision of agrometeorological advisories on plant pest and disease risks. According to them, accurate information on the likelihood of fungal diseases in agricultural crops can typically help professional farmers save the cost of one fungicide application per year. This amounts to considerable savings per hectare. The forecast helps farmers to spray in a more timely and a preventative rather than curative manner, leading to savings in chemical costs and improvements in product quality, since the crops are less affected by the fungal disease that was prevented. The magnitude of these savings gives an indication of the investment in WCI products that is warranted by these figures. The quoted figures are for farms in Western Europe, but the cost of chemicals varies little between developed and developing countries. Moreover, increasing demand for agricultural produce, especially in developing countries, is requiring agricultural outputs to be increased. Accurate agrometeorological information systems are a necessary part of this drive for increased productivity.

The type of information that is probably the most relevant for MSMEs in the agricultural sector is a relatively simple short to medium range rainfall forecast that allows farmers to decide when to plant, apply fertilizer and harvest, and where and when to sell produce. Besides accuracy, location specificity is one of the most important aspects of such a forecast. The kind of accurate downscaling algorithms that are required to downscale global model outputs require hydrometeorological data at high spatial resolutions. Although increasing use is being made of high-resolution satellite data, such as the data provided by Meteosat Second Generation (and, from 2021 onwards, Meteosat Third Generation), near real-time ground data from dense

networks of automatic weather stations (AWS) remain invaluable for this purpose. The latter poses a challenge for many NMHSs, as observation networks are expensive to install and maintain. To ensure that observation networks are sustainable, the focus should be on cost-effective, innovative solutions. NMHS's could opt for the installation of secondary, high density networks of cheap AWSs, fit for purpose and primarily aimed at providing the data required in downscaling algorithms to create user-focused products. Such a network will most likely be installed in addition to the synoptic networks, data from which are made available to the WMO database for use in global forecasts, to yield a different, more pragmatic type of data. In this context, data from the synoptic network are uploaded to the WMO's Global Transmission System (GTS) and used as inputs in global circulation models to create the global, large-scale forecast. These large-scale forecasts, with resolutions in the order of fifty kilometers, can then be downscaled using the data from the secondary, low-cost, high-density network. The higher the density of stations used for the downscaling, the more accurate the downscaled forecast will be. With robust downscaling algorithms in place, location-specific forecasts can become the basis for WCI products focused on MSMEs. Using a location-specific forecast, MSMEs in the agricultural value chain can judge future supply and demand better. They can anticipate shortages or surpluses, and mitigate some of the negative effects that bumper harvests can have on profitability throughout the chain.

Timely, localized, reliable weather information and seasonal forecasts are highly valuable for sectors other than agriculture. One is small-scale fishers, especially on lakes where violent storms can appear suddenly and with very little warning, with deadly results (Snow et al., 2016). Another is tourism, a business highly vulnerable to downturns due to heavy rainfall and other extreme weather events. Transport of goods is another example, as trucking and shipping can be disrupted by adverse weather (Stenek et al., 2013).

The aforementioned examples all deal with MSMEs where production is directly affected by weather conditions. In these examples, the link between increased productivity and the ability to anticipate, adapt or mitigate the effects of weather events is obvious. But there are also a large number of sectors where demand is affected less directly by the weather. Demand for bottled water will increase not only during dry spells, but also during flood periods when waterborne diseases pose a large risk. Higher temperatures due to climate change increase the demand for air conditioning. In India, for example, the increases in air conditioning use already account for as much as fifty percent or more of peak power demand in major cities. There is also a clear link between energy costs and weather, as an increasing share of power is being generated from wind, water or solar. Demand for soft drinks and beer, clothing and many other articles is also affected by the weather. In order to benefit optimally from advance knowledge of changes in the weather or climate, production, logistics and other sensitive processes will have to be flexible enough to allow for sudden increases or decreases in required output. And, even more importantly, management strategies will have to be able to adapt at short notice, based on newly received WCI (Mirasgedis, Georgopoulou, Sarafidis, Papagiannaki, & Lalas, 2014).

Besides the use of WCI in decision-making for purposes of production, logistics, supply and/or demand, weather-based marketing is an interesting, albeit less obvious way to use WCI to optimize the effectiveness of marketing efforts by the private sector. The key to weather-based marketing is the way in which consumers respond to changes in the weather and how location-specific these responses are. Consumers living in arid regions will react differently to rains than consumers living in the wet tropics. There are a number of different strategies for this, namely targeting customers by weather signals and contextualizing, and targeting by signal and adding value.[1] Given the rapid increase in Internet access in most developing countries, even small business owners can profit from these strategies in a cost-effective manner, for example, through the use of social media.

7. Working examples

It is important to realize that comprehensive WCI services require more than a simple investment in modern equipment. The service requires a systematic end-to-end approach (Snow et al., 2016), which starts by ensuring that the observation networks are fit for purpose and that they produce the data that are necessary for the types of products that users require. A system of continuous product development and improvement is required, whereby the focus is on the sector-specific needs of MSMEs, rather than on the technical possibilities of forecasting systems.

[1] See http://www.weatherunlocked.com/resources/the-complete-guide-to-weather-based-marketing/weather-based-marketing-strategies for a complete description of these strategies. The website includes a download link to a White Paper on weather-based marketing.

Stringent quality control and user feedback incorporation mechanisms to ensure continuous product improvement, coupled to a robust and effective dissemination system, are crucial. According to the WMO's Strategy for Service Delivery,[2] 'service delivery should be available and timely, dependable and reliable, usable, useful, credible, authentic, responsive and flexible, sustainable (affordable and consistent over time), and expandable (to be applicable to different kinds of services).'

The market for WCI therefore exists, and it will only increase in importance in years to come. As weather and climate impacts become more severe and deviations from the traditional climate make traditional forecasting less useful, business owners will require the type of WCI products that help them prepare for any adverse effects or opportunities. For these MSMEs, the provenance of these information products will not matter much, whether they originate from the NMHS or from a third party. Given the limited range of WCI products that many NMHSs in developing countries can offer and, in some cases, the variable accuracy of these products, NMHSs are not always the trusted go-to source for entrepreneurs. The provider that provides an accurate WCI product in the most convenient manner, worded in such a way that the user can interpret it and include it in his or her decision-making, will gain the customer's loyalty. With the number of Internet connections soaring, on-line weather services are becoming more easily available. Although the accuracy of on-line weather products varies, the user-friendly products that on-line services can provide and the customer friendly packaging and delivery of WCI products make such services very interesting for consumers and pro-sumers alike. Consequently, partnering with private WCI providers is an interesting and pragmatic option for NHMSs. Through such partnerships, gaps in an NMHS's capacity can be filled, benefiting, for example, the quality, usability and usefulness of WCI products provided by the NMHS. The sheer variety in user needs among MSMEs in different sectors is perhaps the best argument for partnering; it would take a serious investment in capacity and time to enable the NMHS to evaluate all these different user needs and to design the most fitting WCI product to correspond to each need. Partnerships are a much more pragmatic solution to achieving this.

As pointed out in the previous section, user needs vary. MSMEs in the agricultural sector benefit from seasonal forecasts in deciding which variety to plant and to anticipate post-harvest challenges. They will also require medium-range forecasts to decide on the best times to sow, plant, weed or harvest. More specific pest and disease pressure advisories, coupled with advisories on which agrochemicals should be applied and when, can reduce their ecological footprint, prevent crop losses and increase yields. Companies in the logistics sector will need information on the spatial distribution of, for example, rain to optimize their operations in the face of challenging road conditions. The manufacturing industry will need information that can help them, for example, anticipate disturbances in their supply chain or weather-induced changes in the demand for their produce. While most MSMEs will have a rudimentary idea of how weather affects their operations, few use WCI in their decision-making processes. To stimulate the uptake of WCI by MSMEs, gaps in the required characteristics of WCI products outlined in the previous paragraph have to be addressed. For products to be usable and useful, they need to provide information to MSME users to overcome a weather or climate impact on their operations. Thus, MSMEs in agriculture will need highly location-specific, accurate and timely seven-day rainfall forecasts giving them the information they need to decide whether to plant or not and provide agricultural suppliers with the information needed to anticipate increased demand from farmers, thus allowing them to reduce their stocks while continuing to be able to supply their customers. With location-specific forecasts, other MSMEs (e.g. soft drinks suppliers) might be able to anticipate location-specific, weather-induced changes in the demand for specific products, giving them an edge over competitors that do not use WCI in their operations. To ensure the usability and usefulness of WCI, joint product development between NMHSs and MSMEs is crucial. When MSMEs start using WCI, they will in all likelihood come across points for improvement that can be used to develop the WCI further. This requires flexibility and responsiveness on the part of the NMHS. Sustainability in both the delivery of WCI products and continuous product improvement is crucial to ensure that MSMEs continue to use WCI to make decisions.

This presents a huge challenge to many NMHSs, especially in developing countries. Modernization of equipment and systems will make forecasts more dependable and reliable, but will do little to make them more usable or responsive.

[2] 'The WMO Strategy for Service Delivery,' https://www.wmo.int/pages/prog/amp/pwsp/documents/SDS.pdf

To turn the traditional forecast into a product that is just as reliable and dependable, but much more usable for MSME users, requires communication skills not usually found in the traditional NMHS, as well as the skills and capacity to reach out and engage with MSMEs in a variety of sectors, a process that is also foreign to most NMHSs in developing countries.

However, there are numerous examples of private companies that, sometimes in cooperation with the NMHS, have begun to support the provision of tailor-made WCI products specifically targeted at the needs of users. In developing countries, the majority of the potential WCI users targeted by private WCI providers are active in MSMEs due to the relatively large share of the private sector that MSMEs occupy in these countries. These WCI companies target varying parts of the WCI chain, from observation networks and data treatment to product generation, dissemination and the incorporation of user feedback into product development.

The following examples offer insights into various working models for the delivery of WCI services. Note that this list does not contain any recommendation or endorsement; these are merely examples that have been proved to be sustainable and, in some cases, even profitable.

1. Ignitia[3]

Ignitia generates downscaled forecasts, which are produced from lo-resolution (50 km) global weather forecasts using satellite data and a downscaling algorithm to produce a three-kilometer resolution short-, medium- and long-range forecast. Based on this downscaled high-resolution forecast, Ignitia provides location-specific rainfall forecasts through a simple Short Message Service (SMS)-based subscription service to (primarily) smallholders, although the company is looking at branching out into other sectors. Interestingly, Ignitia does not rely on in-situ data to downscale the forecast, but solely on satellite data. In other words, it does not rely on the NMHSs in the countries where they are active.

Ignitia charges relatively cheap annual subscription fees (US$ 3 – 5 per annum) to its subscribers, no doubt the key to the uptake of its service. Ignitia has agreements with local mobile telephone providers for the dissemination of its information products. Its subscriber database of around 100,000 smallholders in Ghana alone (and operations underway in a number of other West African countries) is a good indicator of the willingness to pay for agrometeorological information products among MSMEs in the agricultural sector in Ghana.

The type of products that Ignitia provides, demonstrates how valuable a relatively simple WCI product can be, as long as it corresponds to the users' needs. Interestingly, Ignitia delivers a commercial service, with good accuracy, to a large audience of professional users, without requiring any in-situ observation infrastructure. The quality of its product is based on global forecasts, combined with an accurate, satellite databased downscaling algorithm. As such, Ignitia operates alongside the NMHSs, rather than in partnership with them.

2. Earth Networks[4]

Earth Networks works primarily with NMHSs to provide them with lightning detection systems and, if required, relatively low-cost weather stations. Lightning detection systems act as a proxy for weather radar by relating the triangulation-based information on lightning activity in convective storms (location, direction of movement, intensity and characteristics) to rainfall intensity. Lightning detection networks are significantly cheaper to use than more expensive radar systems, especially in terms of the cost of annual maintenance.

Based on data from its network of sensors, Earth Networks provides a detailed short-range forecast, as well as a nowcast for storm activity, which is used to generate early warning information on hydrometeorological disasters. Besides contributing to observation networks, data treatment and product development, Earth Networks also provides marketing activities aimed at the private sector, such as mining, mobile telecommunications services, and other weather and climate content aggregators, as part of its services to NMHSs.

Its marketing activities, which include in-country market studies, give Earth Networks and the NMHSs with which it works a cross-sectoral insight into WCI needs. This, in combination with high-tech observation and forecasting systems, gives them the ability to cater for a large variety of WCI needs. Again, with MSMEs making up a very significant

[3] http://www.ignitia.se/

[4] https://www.earthnetworks.com/

share of the economies of most developing countries, WCIs targeting MSMEs (notably in the agricultural sector) make up a large share of WCI products and services.

3. aWhere Weather[5]

aWhere Weather provides agrometeorological products aimed at smallholders and works mostly in conjunction with NGOs and governments. Being provided with professional agrometeorological bulletins, smallholders can make informed decisions on specific varieties, fields and cultivation practices.

aWhere Weather consolidates ground data from around the world and creates relevant information products for farmers from these inputs. The products are offered at a high spatial resolution and are made available in a number of different formats, ranging from simple SMS text messages to Application Programming Interfaces (APIs).

The agrometeorological forecast is aimed primarily at farmers. However, aWhere Weather also works with other MSMEs in the agricultural value chain by, for example, assessing the marketing of varieties and farm inputs. This is a great example of how high-tech forecasts can be packaged and tailored to suit the needs of a variety of users. In this case, other non-meteorological information sources are combined with weather forecasts to create a 'higher level', merged information product that corresponds to the specific information needs of MSMEs that are active in the same sector, but in another part of the value chain.

4. Trans-African Hydro-Meteorological Observation network (TAHMO)[6]

The Trans-African Hydro-Meteorological Observation network consists of relatively cheap weather stations that allow the installation of high-density networks, in which the number of stations is given priority over high-tech, high accuracy capacity of the stations. This permits good downscaling and highly location-specific weather forecasts. It is excellent for producing very relevant WCI products to users. An innovative feature of the TAHMO approach is the placement of automatic weather stations (AWS) in schools, which enables possible educational uses, as well as addressing security needs.

TAHMO's focus on high-density networks helps NMHSs overcome one major shortcoming of existing observation networks, namely a density that is insufficient to provide highly detailed, location-specific forecasts. The vast majority of MSMEs operate at small spatial scales and require WCI specific to their areas of operation. The low-cost, high-density networks that TAHMO provides to NMHSs can help the latter produce WCI products and services that are more usable and useful to MSMEs, thus enhancing the sustainable mainstreaming of WCI into MSME decision-making.

5. Human Networks International (HNI)[7]

Human Networks International (HNI), a non-profit dissemination service, demonstrates the very significant public interest in weather information offered in a clear and understandable format. Working in partnership with mobile phone companies and providers of content on health, land rights and other widely demanded information, HNI enables free calling through a '3-2-1' voice-activated network in many local languages[8]. Phone companies have found that the cost to them is offset by increased retention and usage rates in response to the offer of a free service. The ability to offer weather information has been limited by the poor quality of NMHS services in many countries, but where available the demand for such information outstrips that for all other topics.

The way in which HNI delivers WCI helps overcome one major challenge to NMHSs. Pushing WCI, for example, via SMS, to MSME users can become expensive for the NMHS, especially taking into account the large number of MSME users. The business model behind HNI ensures the financial sustainability of the information service. And, unlike information pushes by NMHSs, users can access the information at a time when they need it. The latter contributes to the timeliness and availability of the WCI to MSME users.

6. MeteoGroup[9]

The MeteoGroup cooperates with the Weather Philippines Foundation in the installation of equipment and support for product development, early warning systems, visualization and dissemination. MeteoGroup and the Weather Philippines Foundation have installed over seven hundred

[5] http://www.awhere.com/products/farmer-productivity
[6] http://tahmo.org/
[7] http://hni.org/
[8] http://hni.org/what-we-do/3-2-1-service/
[9] https://www.meteogroup.com/

cost-effective, all-in-one automatic weather stations (AWS) throughout the Philippines. Processing of the data from these stations, as well as forecasting and creating alerts and early warnings, is taken care of by a professional, private, weather services provider, rather than the NMHS. As the weather services provider already has the integrated forecasting platform, automated forecasting systems and communication platforms in place, this leads to significant savings in cost and time to the NMHS when the system is implemented.

The system relies heavily on funding from the private sector, which can derive a benefit from the WCI services provided in return for their funding. The type of extreme weather that the Philippines faces poses a severe threat to the operations of MSMEs. Timely and accurate information, for example, in the form of early warnings that provide sufficient lead time, is crucial for businesses to prepare for extreme events and to reduce the impacts of such events. Many MSMEs that have experienced the impacts of severe weather events in the past are capable of valuing advance warning information. This is demonstrated by the success of the MeteoGroup business model.

7. Insurance products linked to weather observations

In industrialized countries, losses from extreme weather events are often at least partially offset by insurance payments. In developing countries such insurance mechanisms are rare, especially for MSMEs. When such events occur, MSMEs often never reopen, as they lack the resources to resume operation. As small farmers are also highly vulnerable to losses from droughts and floods, this limits their ability to obtain credit for productivity-enhancing investments. The result can also often be much greater costs for donor-supported disaster relief, which takes time to implement and may not meet local needs. One response to this set of challenges has been the design of insurance mechanisms linked to agreed weather events – again a concept dependent on the availability of good local weather data. Programs based on this concept are being designed and implemented at very different scales. African Risk Capacity[10] supports agreed disaster-relief programs paid for by African governments and donors. *Kilimo Salama*[11] is an index insurance program for small farmers in Kenya and Tanzania. Both programs use weather information to trigger payouts (Miller & Swan, 2016a; Miller & Swan, 2016b) (see also section B.1).

By using WCI products to develop insurance products, insurance companies create new use-cases for WCI products. With most MSMEs employing some form of insurance, insurance companies are well informed about the weather and climate risks that MSMEs are exposed to. Knowledge of user needs informs new product development, to the benefit of MSMEs.

Although the private companies described above differ significantly from each other, they do have one thing in common. For NMHSs, partnering with these companies is a pragmatic way to fill gaps in their capacity quickly. In the TAHMO, MeteoGroup and Earth Networks examples, the private company helps the NMHS in strengthening its observation capacities. aWhere Weather, Earth Networks and MeteoGroup support the NMHS' analysis, forecasting and product development capacities, while HNI provides an efficient, cheap and fit-for-purpose platform for the dissemination of WCI products. Insurance companies can build new use cases for, and products based on, WCI, thus enhancing the usability of the NMHS's products. From WMO's Strategy for Service Delivery, it is clear that WCI products depend on a chain of actors and actions, from observation, analysis and product development through to the dissemination and improvement of the WCI. Any gaps in capacity anywhere along this chain affect the quality and sustainability of the WCI product, thus reducing the chances of successful mainstreaming of WCI into MSME decision-making. While training and capacity-building programs can help fill these gaps, in some cases partnerships will be the preferred option. The creation and delivery of WCI products tailored to the specific needs of MSME users and aimed at strengthening the cross-sectoral adaptive capacity of a country's MSMEs is likely to benefit from a form of partnership between private WCI companies and NMHSs.

8. Models and possibilities for cooperation

Judging from the success that private WCI providers seem to be having in developing countries, the markets they are serving deserves special attention from the NMHSs in these countries. Revenues earned from sales of WCI products reduce the reliance of NMHSs on government budgets, while the greater resilience of the private sector to weather and climate anomalies will reduce weather-related losses, enhance domestic productivity and increase tax revenues

[10] http://www.africanriskcapacity.org/
[11] https://kilimosalama.wordpress.com/about/

Table 1. Brief summary of the various CWI initiatives, and their positioning in relation to the NMHS.

Initiative	Positioning	Service
Ignitia	CWI service that operates in parallel with NMHS's.	Agricultural weather and information product, tailor-made to identified user needs. Based on forecasts and satellite data, does not rely on in-situ data.
Earth Networks	Provision of observation, product development and marketing support to NMHS's.	End-to-end solution, from observation to forecast and early warning dissemination, and private sector engagement.
aWhere Weather	Provision of high-tech data retrieval, product development and dissemination support to NMHS's.	Agricultural weather and information product, tailor-made to suit identified user needs. Use of a large variety of data types and sources means that NMHS's can offer a wider range of CWI products and services.
TAHMO	Observation support to NMHS's.	Pragmatic, high density observation networks.
HNI	NMHS support for the user-friendly dissemination of CWI products, and the provision of user feedback to NMHS's.	Dissemination of tailor-made CWI products and services, through a mobile phone based platform that is adapted to the technical capacities of the users. Analysis of the type of information that is accessed provides valuable user feedback to NMHS's.
MeteoGroup	Observation and forecasting support to NMHS's.	End-to-end solution, aimed at strengthening the NMHS's capacity in a rapid and cost-efficient way. Relies heavily on private sector funding.
Insurance	User of NMHS's CWI products, act as individual product developers, creating a unique weather based product. Positioned between NMHS's and users.	Creation of insurance products based on weather and climate data and information. The insurance products create new use cases for basic CWI products and services offered by the NMHS.

for the government. Especially the increase in tax revenues resulting from the inclusion of WCI by MSMEs is a key argument for government spending on WCI. The country-wide benefits derived from improved WCI were estimated by Hallegatte (2012) at 6–10% of additional benefits, on top of the benefits in terms of reduced losses to lives and assets from hydrometeorological disasters, which can be achieved through, for example, early warning systems. Crucially, the increased government revenue from increased domestic productivity will exceed the revenues that the NMHS could generate from the marketing of WCI alone.[12] Consequently, investments in WCI products and services make a lot of sense. Depending on the needs, priorities and gaps in NMHS capacity, different models for cooperation may be chosen to modernize the creation and delivery of WCI. While most NMHSs might initially prefer to use training and capacity-building to fill their capacity gaps, in reality a WCI products cooperative model where the NMHS and a private WCI provider work together on the information service is likely to be more effective and more readily achievable.

One of the first challenges will be to develop and sustain a good working relationship between the providers of WCI and its users. The NMHS, possibly in partnership with a private partner charged with customer relations, must ensure the continuous high quality of these products and develop a sustainable model for the reliable delivery of accurate, timely and actionable information products. Continuous product development must be ensured, and user feedback must be incorporated in order to ensure that WCI products remain relevant to evolving user demands. Besides this, the proper functioning of the organization must be ensured, with NMHS staff receiving training throughout their careers, observation networks being maintained, updated, modernized and expanded, and robust procedures put in place for the observation, data management, product development, forecasting and delivery of information products. All the links in the WCI chain are crucial, and an acute awareness of weaknesses through continuous

[12] This, of course, follows from the business case of mainstreaming WCI into MSME decision-making processes; the use of WCI by MSMEs provides the MSME with an economic benefit, which outweighs the cost of the WCI. If this is not the case, the MSME will not use the WCI. In that case, the design of the WCI product is faulty; either the content does not correspond to the need, or the WCI product is overpriced.

self-assessment of the weakest links is needed to ensure sustainability.

As many NMHSs do not currently provide products to private MSME users, it is all too easy to underestimate the changes required in the NMHSs' attitude towards commercial WCI products if their future relationships are to be mutually beneficial. A partnership with a commercial weather information provider can help prepare the NMHS for what is to come. Partnerships with mobile phone companies may also be helpful and mutually beneficial, as mobile phone services are very competitive in many developing countries, and the delivery of weather information, including emergency alerts, will add value for consumers.

Product development aimed at the private sector requires a basic knowledge of the highly diversified private sector and the skills to identify how weather and/or climate affects a certain business. This is hindered by the fact that few private-sector players will have anything beyond some basic meteorological skills and will therefore be in the dark regarding what kind of products an NMHS could provide. The NMHS has to identify the specific need for WCI products and develop such a product. Then the product has to be readily understood by the WCI consumer and produced in a form useful to him or her. In addition, as more WCI users become more familiar with the information and its usefulness, more feedback on possible improvements of the products will be generated. Consequently, and in order to keep WCI users satisfied with WCI products, the NMHS must continuously improve the latter.

These are challenging tasks for previously purely science-focused organizations, and significant institutional change is required to transform traditional NMHSs into market-oriented, customer-friendly organizations. This transformation might be considered undesirable by some NMHS staff members, who believe the NMHS should focus on its core scientific activities. In these cases, one option could be to partner with a private company (e.g. some of the organizations described in this paper) that specializes in this type of product development and delivery. Profit-sharing agreements could make this a win-win situation, where the NMHS benefits from the commercialization of its products without having to make major changes to its organization. Obviously, hybrid versions are perfectly possible, including options where a private company guides the NMHS in its transformation into a more commercially focused body. In such a scenario, the private partner could assist the NMHS in, for example, the identification of market opportunities or in a certain level of product development. In this case, the NMHS could choose to carry out the actual marketing efforts. The best suited transformation pathway for individual NMHS will depend on each country's vision and long-term strategy for its NMHSs.

One relevant precedent may be the Royal Dutch Meteorological Institute (KNMI).[13] This agency has invested in commercial activities in the past, but it has been split into a commercial and non-commercial branch. The latter focuses on the management of the observation network, public weather forecasts, the provision of weather information as a public good and early warnings for hydrometeorological disasters as some of its core functions. Interestingly, the hugely successful commercial branch of the KNMI only accounts for some 15% of the KNMI's annual budget. For the remainder, the KNMI still relies on government funding. From the example of the KNMI it is clear that it is a perfectly possible solution to have the NMHS focus on its core tasks, which are the management of the observation network and database, the provision of weather information as a public good and issuing warnings of weather hazards, while commercial activities are left to third parties.

The dissemination of WCI products is a challenge in its own. Especially when targeting MSMEs in the agricultural value chain, the number of users, especially in agricultural economies, can be very large. If the choice is made to disseminate information via SMS text messages, the cost to the NMHS will be exorbitant. Intermediaries, such as extension workers or farmer cooperatives, could assist in delivering information to users through established dissemination networks. An interesting option for paid-for information products would be a cost-sharing model between a mobile telephone provider and the NMHS or a private weather provider. Besides covering the costs of dissemination, cooperation with a mobile telephone provider makes invoicing users a lot easier and more efficient. This is the model that Ignitia uses, among others. The importance of receiving feedback from users and consequently of providing a simple system to provide feedback also needs to be taken into account when deciding on the method of dissemination. Another option in overcoming this challenge

[13] http://www.knmi.nl/over-het-knmi/about

is to bundle WCI products with various other information and value-adding services.

9. The need for institutional and legal change

Exclusivity mandates only go so far in preventing private entities from providing services in a country. Even if an NMHS is granted the sole right in the entire country to provide WCI products to the public, as is the case in Uganda, there will always be ways to work around the rules. Ignitia, described above, is a case in point. The company does not rely on in-situ observations, but creates accurate downscaled forecasting products using available forecasts and satellite data. Smartphone weather apps are another example. These come pre-installed on most modern smartphones and provide basic weather information and forecasts, obtained from other sources than the NMHS, to mobile phone users. Although their accuracy might not be the same as what modern NMHSs could provide using data from their state-of-art observation networks, this information is often enough to satisfy the basic needs of the private user. The same applies to websites offering international forecasts. In other words, shielding the market from private WCI providers is not a pragmatic solution. Policing the mandate mentioned above, i.e. ensuring that such weather apps or websites are not used, is impossible.

Rather than outlawing private weather providers, a more sustainable option would be to embrace them and work together with them on product and market development. An assessment of the market for weather information in Africa commissioned by the UNDP CIRDA program[14] points to experience in the US as illustrative.

Since 1946, when the first private weather companies started operation, the commercial weather sector within the USA has grown to ~350 companies. This rapid growth of the commercial weather market is largely a result of the US government providing free and open access weather data. It is difficult to calculate the size of the entire climate and weather-related industry, since many of these companies are privately held. However, in 2013, the University Corporation for Atmospheric Research (UCAR) estimated gross sales of weather products and services at US$3 billion per annum, and the value of the entire industry at US$6 billion per annum (Mills et al., 2016: 37).

[14] http://adaptation-undp.org/projects/programme-climate-information-resilient-development-africa-cirda

The observational data and local knowledge of the NMHS will help improve WCI products. The private entity's skills in marketing WCI products can help improve the marketing potential of products provided by the NMHS. To give the NMHS the freedom to develop the market for WCI products and/or to freely engage with private WCI providers, they will require a legal framework to be put in place that allows them to do so. In many countries, the NMHS will have become a (semi-) autonomous entity, such as an agency or an authority, before its products can be marketed.

In recent years, a number of African countries have undertaken such steps. Uganda's Directorate of Meteorology has been transformed into the Uganda National Meteorological Authority by the UNMA Act of 2012. The newly created UNMA has the right to market WCI products. One long-term aim of the UNMA Act is to decrease the UNMA's dependence on government budgets and allow it to become more self-sufficient. In the future, revenues generated from the sales of WCI products can support its maintenance and trainings programs, thus improving the sustainability of investments in WCI products. This, in turn, will ensure the sustainability of WCI services, which is crucial for helping MSMEs adapt to climate change. Besides Uganda, Sudan and Egypt also have meteorological authorities.

Besides the meteorological authorities, which enjoy a large degree of autonomy, a number of NMHSs in Africa have been transformed into agencies. Although these meteorological agencies are not quite as autonomous as the meteorological authorities, most meteorological agencies are allowed to develop commercial activities in the same way that authorities can. Benin, Senegal, Djibouti, Tanzania, Nigeria, Ethiopia, Ghana and Rwanda all have meteorological agencies.

Of course, the exact scope and mandate of a meteorological agency compared to those of a meteorological authority is very country-specific. The change in status from a government department to an entity with more independence relies on a proper understanding of the functioning of NMHSs by political decision-makers. The government has to realize that NMHSs are not typical government entities. NMHSs operate large and expensive observation networks, they need highly specialized skilled staff, and they have high running costs due to their maintenance and training requirements. To be able to sustain their observation networks and provide

relevant WCI products to the private sector and to other government institutions, they need a certain degree of autonomy to ensure sustainability.

Interestingly, the performance of NMHSs in many developing countries has few implications for their annual budgets. Not much is currently expected from the NMHSs, and there is little to no demand for accountability in terms of, for example, the relevance of outputs, the quality of forecasts, or the impacts and benefits of early warning systems. As pointed out in the above, the potential benefits of accurate and timely WCI products are considerable. However, in order to realize them the WCI chain has to function properly, and existing gaps in the NMHS's capacity have to be addressed. In some cases training and capacity-building programs might be sufficient; in other cases public-private partnerships might be the most appropriate and pragmatic solution. The latter might necessitate policy changes regarding, for example, the government's data policies. But the key point is that, by focusing on the production of accurate early warnings, good quality forecasts and the provision of tailor-made WCI products to the private sector, the NMHS will become more relevant, and the government will realize that investing in the NMHS is money well spent.

10. Conclusion

Nearly all sectors can benefit from WCI products, even though the need might not have been identified by all MSMEs. The need for such information products for the agricultural sector is very clear due to the strong link between favorable growing climates and good yields. But there are many other sectors that require WCI products that are timely, accurate and actionable for use in decision-making processes. Identifying the impacts that weather and climate have on a specific business, followed by the development of an information product that allows a business owner to prepare for, adapt to and mitigate the effects of a certain weather events, takes skills that are not always available in most NMHSs. However, in order to adapt effectively to climate change, such adequate, tailor-made WCI products aimed at the needs of the private sector, as well as the government and the public, are crucial. Only when WCI is available and mainstreamed in decision-making processes throughout society will a country's resilience to climate change be enhanced.

Many of the successful and sustainable WCI services aimed at MSMEs in developing countries are driven by private WCI providers, who have identified needs for information services that are currently not provided by the NMHS. Although some of these initiatives are donor-funded, more and more of these companies are applying a sustainable commercial model. In some cases, this model includes the NMHS, as well as mobile telephone providers. The latter are very interesting partners, primarily due to their ability to ensure efficient and targeted dissemination of messages, and the possibilities for earnings models based on mobile subscriptions that this offers. Mobile providers are experts at getting the message across to the targeted user, and they offer an easy way to obtain user feedback. With security, power, transmission and site rental among the perpetual challenges for NMHSs, mobile providers can offer a solution by hosting equipment on their GSM towers (see Bakhtin, koldaev, Lanin, & Sarychev, 2012, for more information). Cooperation between private WCI providers and NMHSs is conceivable at various levels. The involvement could be limited to training for NMHS staff provided by the private company, or the private company could take over the entire product development and marketing of WCI products, as well as run components of the observation system. The best choice depends very much on each country's situation, the capacity of the NMHS, the challenges each country faces and the private-sector landscape.

Automated access to international databases has made it possible to develop very high-quality WCI products, with limited reliance on in-situ observation systems. Global forecast outputs are widely available and accessible via APIs, as are data from the rapidly growing number of weather and earth-observation satellite platforms. Spatial and temporal resolutions of satellite data, as well as the number of available wavelength bands, offer a wealth of useful information for meteorologists and hydrologists. This has opened up the market for WCI products to international providers, who are not necessarily based in the countries where they provide their services.

Admittedly, several of the privately run initiatives mentioned earlier are funded by donors, and questions about the sustainability of these projects are in some cases justified. However, an increasing number of them have managed to develop a marketing model that sustains their information services and, in certain cases, makes them profitable. This makes the case for a re-orientation of the traditional and notoriously underfunded NMHSs. Through e.g. establishing public-private partnerships with private weather companies,

the NMHS's can start exploring these potentially profitable links in the WCI chain.

Interestingly, the priority for NMHSs in certain countries is on investments in state-of-the-art synoptic stations, thus improving the quality of the data that are being uploaded to the WMO's Global Transmission System. This is good news for the quality of global forecasts, but it will have only a limited impact on the relevance of the WCI products that are being provided by the NMHS, as coarse-resolution, high-quality networks provide a limited number of data points that can be used for downscaling forecasts. If anything, this focus on synoptic stations is likely to result in improved quality of the WCI products provided by third parties as the quality of global forecasts improves. Obviously, investments in good-quality synoptic observation stations for use by the global meteorological community and in relatively inexpensive, fit-for-purpose stations meant for downscaling, forecasting and the development of tailor-made WCI products are both necessary. However, it is investments in the latter that will have the greater effect on the long-term sustainability and national relevance of NMHSs.

The increase in Internet access and Internet use by MSMEs poses a number of opportunities and challenges to NMHSs. Clearly, the demand for WCI products among MSMEs exists, and it will only increase in years to come. When business owners see the usefulness of accurate WCI products, they will invest in such information products themselves. When there is a market for an information product, either the NMHS or private providers will start providing MSMEs with these products. The long-term strategies of NMHSs will determine their role in the future market for WCI products. They could either become an interesting partner for third-party WCI providers, or they could see their role being limited to the maintenance and operation of expensive observation networks, without reaping the benefits of the potentially lucrative market for WCI products aimed at MSMEs.

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Climate Expert: a bottom-up approach to SME resilience to climate change

Abstract

SMEs are affected by extreme weather events and by the slow onset of changes to the climate, such as water scarcities, flooding and heat waves. At the same time, SMEs play a key role in supplying goods and services to the population. If engaged effectively, the private sector, and especially SMEs, is uniquely capable of developing locally relevant, effective adaptation solutions, which can increase the resilience of society due to the vital role of SMEs within communities.

The Climate Expert approach developed by the GIZ program 'Strengthening the Capacities of the Private Sector to Adapt to Climate Change' (PSACC) on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), described in this article, aims to provide approaches and tools to strengthen the resilience of SMEs. Experiences from SMEs in the four pilot countries of Bangladesh, Costa Rica, Morocco and Rwanda have certain similarities and suggest that these insights will also hold true in other contexts.

1. Why SME adaptation matters for building resilience

In developing countries, the private sector mainly consists of Micro Small and Medium size Enterprises (MSMEs). According to the Organization for Economic Cooperation and Development (OECD), they count for at least 95% of all businesses and provide 60-70% of jobs worldwide (OECD, 2000). (M)SMEs also play a key role in supplying goods and services to the population.[1] SMEs are affected by extreme weather events and by the slow onset of changes of the climate. Impacts like water scarcity, flooding and heat waves can hamper and interrupt business operations and supply chains both directly and indirectly, thus threatening business continuity, jobs, livelihoods and economic growth.

For various geographical, economic and social reasons, developing countries and emerging economies are particularly affected by the adverse effects of climate change. Concerted efforts by the public sector, the private sector and civil society are necessary to tackle this global threat by building the resilience of societies and economies. Climate change impacts can quickly become urgent and then have the capacity to limit growth potential or even threaten the survival of SMEs. Therefore, SMEs' provisioning services, jobs and economic growth can be harmed by climate change.

If engaged effectively, the private sector, and especially SMEs, is uniquely able to develop locally relevant, effective adaptation solutions which can increase the resilience of society due to the vital role of SMEs within communities. However, the role of the private sector in contributing to climate adaptation is mostly interpreted as one of financing adaptation, rather than driving and shaping adaptation efforts, without differentiating the diverse actors within the private sector (multinationals, financial institutions, SMEs, etc.).

The Climate Expert approach developed by the GIZ program, 'Strengthening the Capacities of the Private Sector to Adapt to Climate Change' (PSACC) on behalf of the German Federal Ministry for Economic Cooperation and Development, described in this article, aims to provide approaches and tools to strengthen SME resilience. These were tested in four different countries: Bangladesh, Central America/Costa Rica, Morocco and Rwanda (GIZ, 2015).

2. Business survival and growth: key considerations for SME adaptation

The four-year program, 'Strengthening the Capacities of the Private Sector to Adapt to Climate Change (PSACC)' of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), was commissioned by the German Federal Ministry for Economic Cooperation and Development. The main objectives of the program are to test different approaches in raising awareness and building capacity for climate change adaptation of SMEs in selected pilot countries and to anchor the topic in development cooperation. Experiences made in the different countries and various sectors show important similarities and suggest that these insights will also hold true in other contexts.

2.1 SMEs can be engaged in adaptation discussions

A key insight of GIZ's activities is that SMEs need to be addressed in a language and with concepts that reflect the realities of their businesses. In the project's approaches and documentation, adaptation is therefore presented as an additional element of corporate risk management, a key to increased competitiveness, or an opportunity for companies to develop new products and services that respond to adaptation needs.

It can be observed that, especially in vulnerable regions, some businesses are already investing in adaptation measures without identifying them as such. One of the key messages based on experiences in different countries was that SMEs are in principle willing to invest in adaptation provided the business advantages are sufficiently clear. In order to accelerate the adaptation dynamic, SMEs need to be aware of the risks and opportunities that result from climate change (UNEP FI and GIZ 2016). However, access to finance, both generally and specifically for adaptation, constitutes an important barrier. The project develops evidence and case studies to demonstrate that adaptation strategies for SMEs are necessary for their survival, as well as supporting their efforts to stay competitive and realize new business opportunities. Investment in adaptation is therefore driven by three factors: a) expected reductions of risk, b) reductions in costs, and c) the creation of new opportunities and the expectations of future revenues (UNEP FI & GIZ, 2016).

[1] While micro-enterprises were considered in the project described in this article, the article itself focuses on the project's experiences regarding SMEs, as micro-enterprises face additional challenges when confronting climate change.

Figure 1: Rationale for adaptation (GIZ PSACC 2017a)

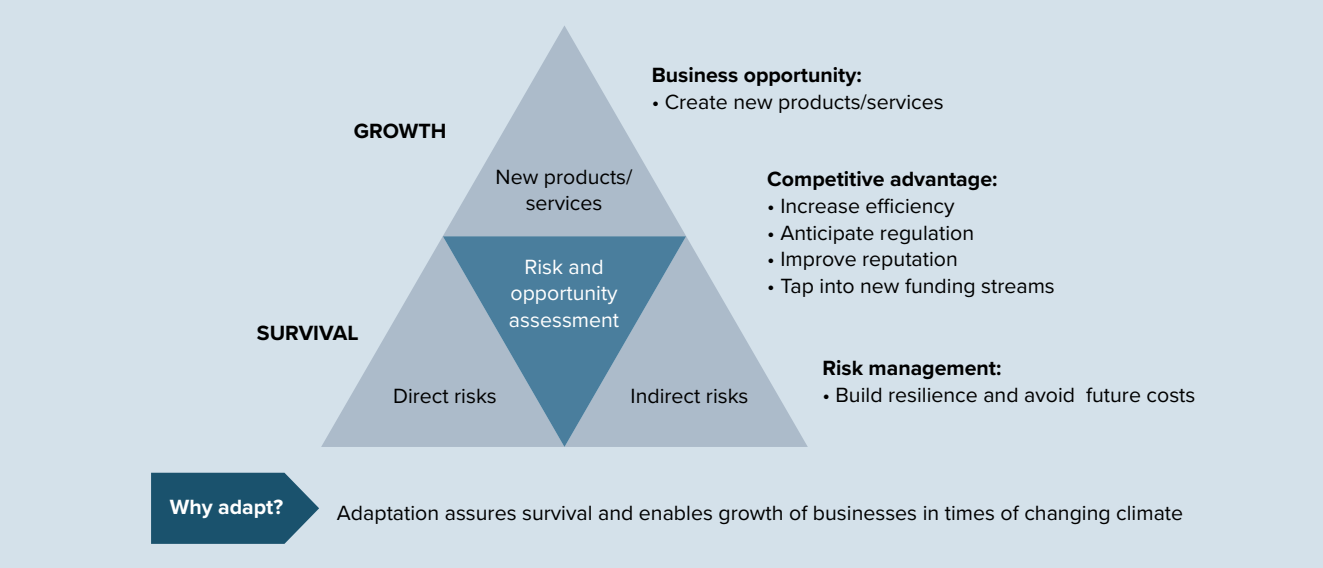
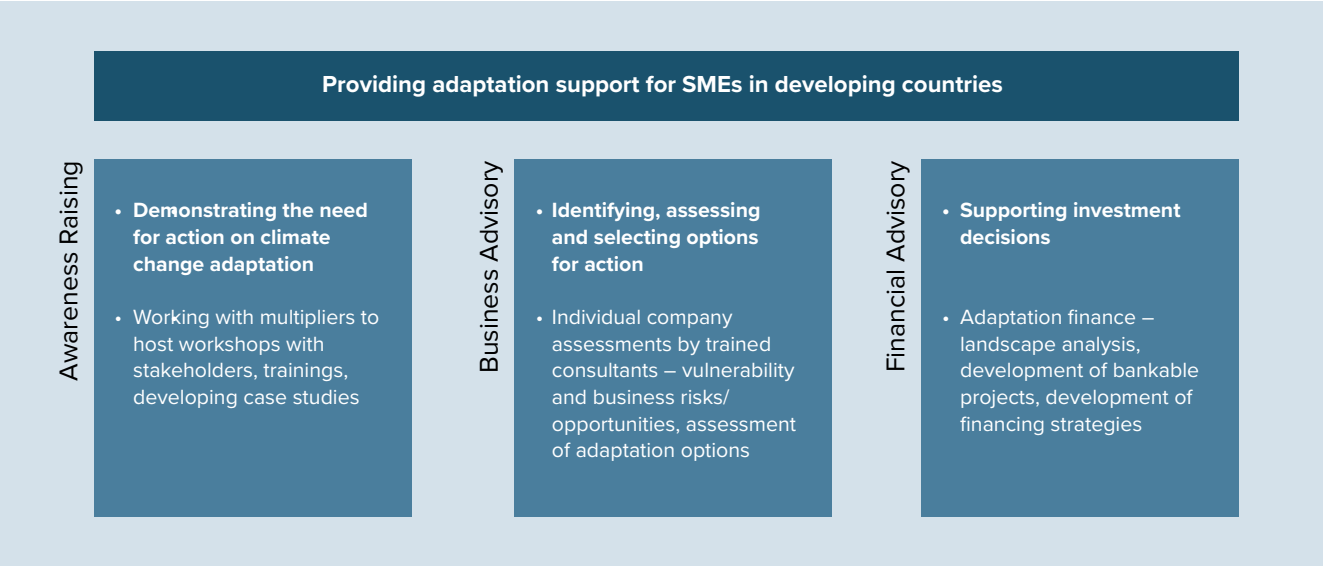


Figure 2: Pillars of SME adaptation (GIZ PSACC 2017a)



2.2 Support for private-sector adaptation needs to be built upon three pillars

Experiences made throughout the project can be summarised in the form of three pillars that build the basis for private-sector adaptation support:

Awareness raising: demonstrating the need for action on climate change adaptation

In order to generate the necessary interest and willingness to act on the part of company management, focusing first on awareness-raising activities has proved effective. The link between adaptation and business growth and survival is often not immediate enough for companies to invest in adaptation measures, especially when climate change indirectly affects the company through its value chain or stakeholders. However, in the experience of the GIZ project, companies will act on climate change if there are demonstrable consequences for their bottom line (see 5.2). Companies required concrete evidence of the need and opportunity for action on climate change, which

the project provided by showcasing the experiences of entrepreneurs or companies that had already successfully implemented adaptation measures.Several SME case studies from different sectors in the pilot countries are available for download on the projects homepage, www.climate-expert.org. Awareness-raising activities were particularly effective when multipliers, such as business associations, chambers of commerce, industrial zones and training institutions, were involved as partners to motivate and inform SMEs (see 5.6).

Business advisory: identifying, assessing and selecting options for action

The general awareness of climate change issues is often not sufficient for companies to act on adaptation. In the experience of the project, this can be challenging, as many SMEs have other priorities and thus will not invest time or resources in adaptation strategy development. Rather, SMEs initiate action only if they see clear business advantages in assessing and managing climate-related risks and opportunities and if they receive the necessary support to do so. In countries where business consultancy services and networks routinely support companies, the use of consultants to motivate and drive SMEs' adaptation activities proved highly effective. Consultants were trained specifically to guide companies through the adaptation strategy development process, e.g., with the Climate Expert Tool (see Figure 3). The SMEs supported by these consultants profited from both their specialized knowledge and their implementation experience. However, SMEs were often reluctant or unable to finance the consultants' work. Therefore, financial support from the public sector or development organizations was identified as a key factor for SME action by the project. These stakeholders were able to co-finance the climate risk assessments and strategy developments in order to incentivize the uptake of consultancy services, thereby increasing the resilience of SMEs and the economy.

Financial advisory: supporting investment decisions

Based on project experience, mobilizing financial flows for adaptation measures is a very important element and a key challenge. Generally, SMEs have difficulties in accessing finance, and the additional need to invest in climate change issues will likely increase their financing gap. One key result of the adaptation strategy process is the prioritization of adaptation measures and the identification of the most appropriate and most financially viable ones. This can include a cost-benefit analysis (CBA) specifically targeted to potential climate change scenarios. After the assessment has been completed, it has proved helpful to continue advising the company with regard to possible funding opportunities or monitoring strategies.

3. Implementing a Methodological Approach to SME adaptation

3.1 Tools and training for vulnerability assessments

The project is based on the **Climate Expert approach** for the SME sector, which offers a) a methodology for raising awareness, b) training opportunities, and c) a tool to support SMEs' adaptation efforts in analysing their individual vulnerabilities and to identify adaptation measures. This tool was developed for businesses and includes a risk assessment, the identification of suitable adaptation measures, a cost-benefit analysis (CBA) and drawing up an adaptation strategy (Climate Expert risk assessment tool).

The Climate Expert risk assessment tool considers both direct impacts on the companies' buildings, processes, logistics, stock, employees and surrounding communities, and indirect impacts through changes in the market, financial landscape and regulatory environment.

Within the Climate Expert risk assessment tool, seven impact areas are analysed where climate change can potentially affect a company. This varies from impact areas outside the business, like stakeholder or market considerations, to operational considerations like logistics. Impacts on all of these areas can significantly affect a company's business activity and are therefore considered in this assessment.

3.2 Implementation in Bangladesh, Costa Rica, Morocco and Rwanda

The Climate Expert approach was **tested** in four pilot countries: **Bangladesh, Central America/Costa Rica, Morocco and Rwanda**. After conducting desk studies on vulnerabilities as the starting point, the project approached private-sector multipliers, which supported and accompanied awareness-raising activities and trainings. The project tested the Climate Expert risk assessment tool with selected companies. Subsequently, local consultants and other business providers were trained in the Climate Expert risk assessment tool in order to support further companies. The results of the risk assessments at the company level were summarized in the case studies (GIZ PSACC, 2017b). The overall project approach was similar in all countries.

Figure 3: Climate Expert risk assessment tool for enterprises (GIZ PSACC, 2017a)

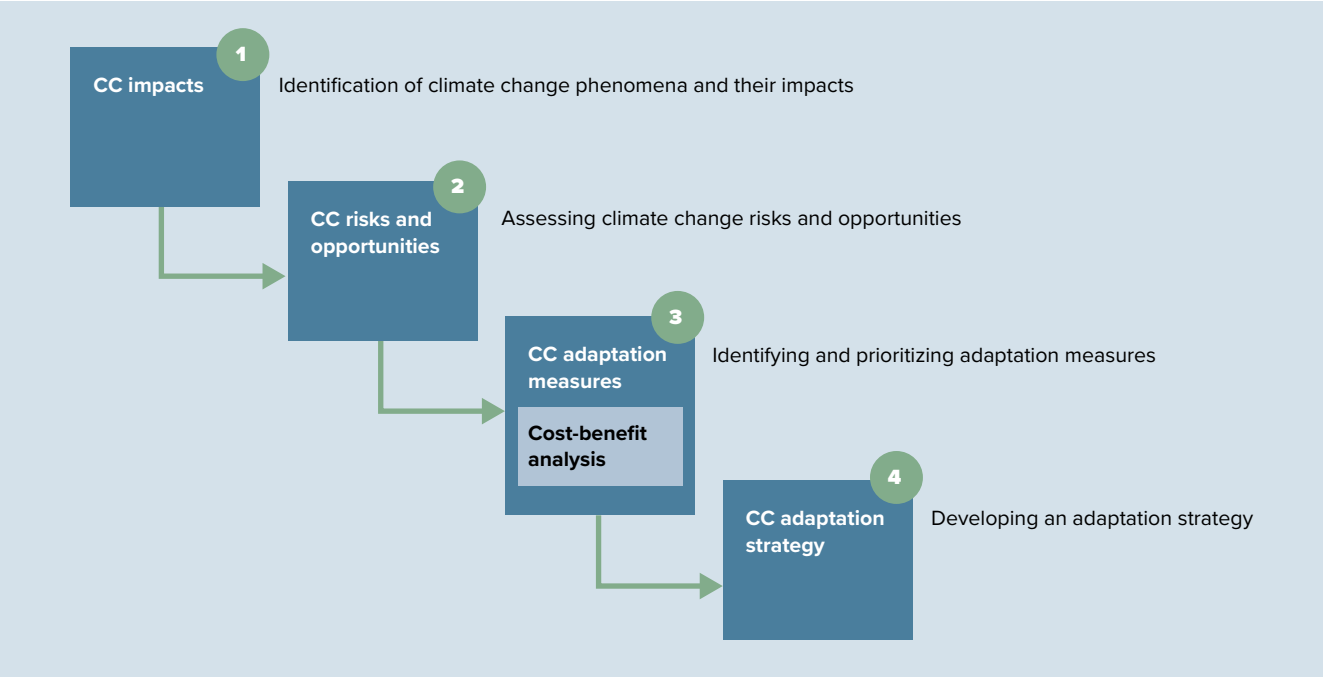
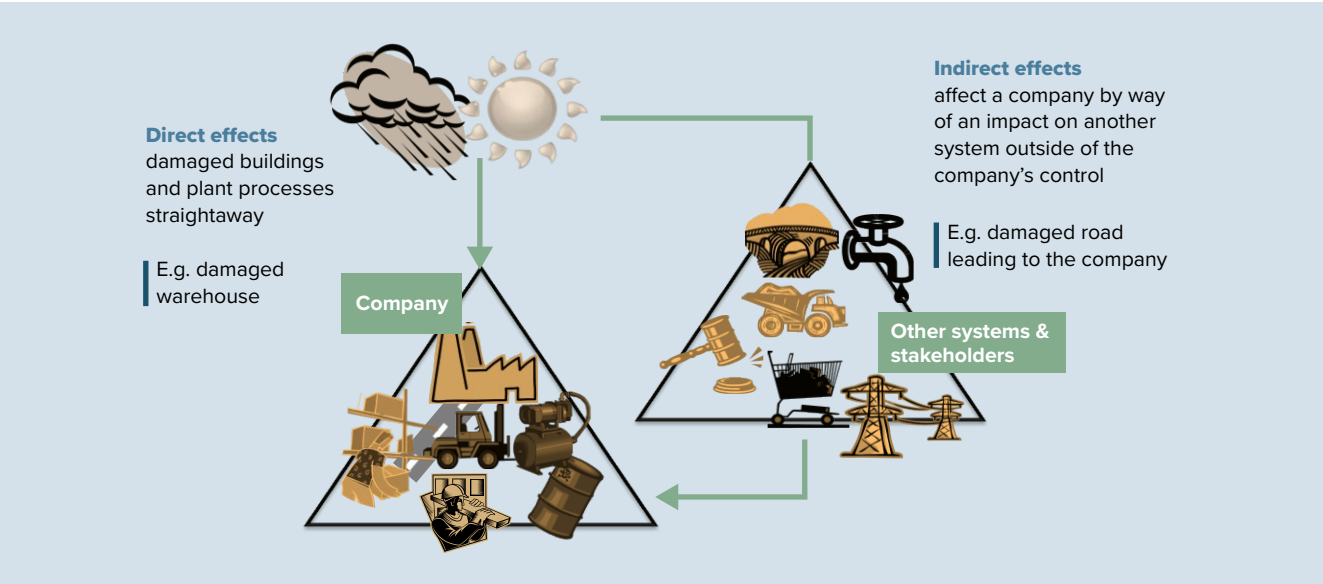


Figure 4: Direct and indirect effects for businesses (GIZ PSACC, 2017a)



3.3 Selection of countries, sectors and partners

In the preparatory phase of the project, a selection rationale was used in order to ensure the relevance and effectiveness of the project's interventions. Three criteria were chosen for screening all partner countries included in German development cooperation:

- Current and projected vulnerability from climate change
- Existence of a strong private sector and value-adding activities
- Political stability

Figure 5: Climate Expert assessment grid for impact areas (GIZ PSACC, 2017a)

Infrastructure & processes	**Buildings & location**	E.g. building damaged by flood
	Processes	E.g. overheating of machinery
	Logistics & stocks	E.g. delivery delays due to flooded roads
Stakeholders	**Employees & community**	E.g. reduced productivity due to heat stress
	Government & regulation	E.g. stricter regulation to save water
Market & finance	**Market**	E.g. lower acceptance fossil-fuel based products
	Finance	E.g. requiment to have adaptation plan

Figure 6: Climate Expert Approach in pilot countries (GIZ PSACC 2017a)

1. Desk studies on climate change phenomena and impacts for the respective countries/region were conducted
2. In cooperation with the multiplier organizations, awareness raising workshops were implemented during which the specific needs and challenges of the selected sectors were discussed with the target groups
3. Pilot climate risk assessments (based on the Climate Expert Tool) were conducted with SMEs, one industrial zone and one tourist destination
4. Consultants and multiplier organizations were trained to use the climate expert risk assessment tool themselves with their members or affiliated companies
5. Throughout the project, country- and sector-specific strategies for financing adaptation measures were explored with implementing partners and SMEs

Using these criteria as a basis, additional 'soft' factors were considered, including the probability of engagement in adaptation by sector actors as indicated by their previous experience with climate change impacts, their familiarity in dealing with wider sustainability issues, etc. Another objective of the selection of sectors was to ensure some diversity in the possible impacts on businesses (flooding, droughts etc.) in a variety of business contexts (service sector, industrial sector, agro-processing sector, etc.).

The selection process for identifying the project partners and multipliers was similar in each country. In **Bangladesh**,

Table 1: Overview of selected countries, sectors and implementation partners (GIZ PSACC, 2017a)

Country / Region	Selected sector	Implementation partners
Bangladesh (Khulna)	Transport/shipping/ rice mills/ light engineering	Sector associations, training institution
Costa Rica (Monteverde)	Tourism	Chamber of Ecotourism and Sustainable Tourism, Ministry of Tourism
Morocco (Agadir/Souss Massa Draa)	Fish processing, agro-processing Industry	Industrial Zones association (chambers)
Rwanda (no specific region)	Coffee, manufacturing	Sector associations, NGOs

the city and region of Khulna were chosen due to their increased vulnerability to climate change and their economic importance for Bangladesh. Here, the water transport sector was singled out as a sector of high relevance for resilience-building measures. The regional and sectoral approach in Bangladesh led to cooperation with industry associations such as the light engineering association, the rice mills association, the cargo vessel owners' association and the dockyard owners' association in the Khulna region. The Bangladesh Institute of Management (BIM) became an important partner in disseminating training on climate adaptation for the private sector, especially regarding climate impacts on value chains.

In **Costa Rica**, the tourism sector was chosen due to its high importance and vulnerability and the fact that most of the businesses serving the sector are SMEs. In a baseline study, the tourist regions and the regions that were highly vulnerable to climate change were mapped. During a first stakeholder workshop with major players of the tourism industry, a steering committee ("Comite consultivo" or CC) was established. This step contributed significantly to the success of the project, as these key players have a significant influence on SMEs in the Costa Rican tourism sector. The CC played a crucial role in upscaling the Climate Expert approach from pilot level to national level, as well as in mainstreaming the approach among tourism SMEs after the pilot phase (see 5.6).

In **Morocco** the Souss-Massa Draa region was identified. It was decided to partner with the management of established industrial zones (IZ) and stakeholders from the public sector (e.g., municipalities, chamber of commerce, regional investment authorities and the local government). Working with IZ allowed working with all companies located in these areas. For example, in partnering with IZ Ait Melloul, approximately three hundred SMEs were located. A steering committee accompanied and supervised the different activities. The results that emerged from the regional level have now been transferred to national level, and, as a new implementing partner, the association of Eco Industrial Zones in Morocco (COZINE) is disseminating the approach to its more than thirty members (Conjoncture, 2016).

In **Rwanda**, the results of a baseline study on climate vulnerability were presented in a multi-stakeholder workshop with representatives from the public and private sectors. Based on the results elaborated in the workshop, the coffee and manufacturing sectors were chosen as pilot sectors due to their high levels of vulnerability and great importance for economic development. All sectors have sector associations that were consulted to act as multipliers for the project. Initial interest on the part of these multiplier organizations existed, but they had neither the means nor the capacity to act as 'real' multipliers. In order to be qualified as such, the sector organizations would have needed substantial financial support, as well as assistance in organizational development. Instead of sector associations, the project succeeded in collaborating with the Albertine Rift Conservation Society Rwanda (ARCOS Network) in mobilizing SMEs.

4. Two Practical Examples of Climate Risk Assessment for Companies

4.1 Bangladesh: M/S Rocky Dockyard, Khulna

In Bangladesh, the **Climate Expert risk assessment** tool was implemented with M/S Rocky Dockyard. M/S Rocky Dockyard is a family-run business founded in 1992 and registered in Khulna. The company offers two kinds of services: cargo transport, which covers 70% of its business,

and the dockyard, which covers 30%. Dockyard services are mainly repair services and the construction of new (cargo) vessels and pontoons, Repairing ships is the main activity in the dockyard. The company employs twenty permanent and eighty temporary staff. According to how SMEs are defined in Bangladesh, the company is considered to be medium-sized.

The company was selected by members of the Dockyard Owners' Association of Khulna. One reason behind this choice was the fact that Rocky Dockyard's CEO was the president of the association, thus making the company a good industry representative and allowing it to disseminate the assessment results among the association's members effectively. The process was initiated through a meeting with the company's CEO, during which the company's climate risks were identified.

First step: climate change impacts:
Information on climate phenomena and impacts for the region was provided by the project. Using the Excel-based assessment grid of the Climate Expert (Table 2), the influence of these climate change phenomena on the **seven impact areas of the company** (see Figure 4) was then analysed. For instance, in the case of **locations and buildings,** cyclones pose a risk to the company, as the storms could carry a ship away from the dockyard and damage it significantly. The company's location is sensitive to heavy rainfall because of the adjacent river. Floods, which are caused by heavy rainfall, lead to river erosion and create stronger siltation of the river banks. Because the ships cannot operate in this situation, these impacts endanger business continuity. Regarding the '**processes**' impact area, the cargo business is affected by the increasing number of storms, which complicates the reloading of goods from the anchored motherships to the company's smaller ships. In the past, transporting cargo has had to stop completely for several hours or even longer. Rough weather makes the ship's navigation more difficult, and an increasing number of accidents have occurred during extreme weather conditions. This is an enormous cost factor for the company. Aggravating factors are the lack of basic navigational equipment like navigation charts, GPS, weather stations, echo sounders or sonar systems on the ships.

Second step: risks and opportunities
Following the assessment of M/S Rocky Dockyard's exposure to climate change risks, possible adaptation measures to mitigate the risks and to realize the opportunities were

Table 2: Adapted climate expert risk assessment for M/S Rocky Dockyard (GIZ PSACC, 2017a)

	Climate phenomenon	Impact area			Resulting risk	Description	Expected timeframe
		Infrastructure and operations	Stakeholders	Finance and market			
1	Changing rainfall pattern/decrease in water levels	x			Limited possibility to slip the ships in winter time in the dockyard	Longer droughts which leads to decrease in water level; winter season, he can only pull and drop ships for 6 days a month; on the other days slipping of ships is not possible	6-10 days possible and 20 days a month you cannot lift (Nov-March)
2	Changing rainfall pattern/decrease in water levels	x			Cannot unload goods from mothership: docking undocking not possible	Only small boats are able to unload if water level decrease	

Table 3: Climate change impacts and related adaptation measures for M/S Rocky Dockyard. (GIZ PSACC, 2017a)

Climate Impact	Cargo Service	Dock yard	Risk for Company	Selected Adaptation Measures
Rising temperatures	Medium	High	• Lower productivity of workers • Energy interruptions • Lack of affordable alternative electricity generation • Slipping challenges	• Fixed shade construction/Tree plantation • Training on energy efficiency/ energy-efficient electrical appliances • Deployment of solar system
Storms	High	Low	• Interruption of Cargo service • No or half loading activities • Accidents/safety challenges	• Improved weather information • Navigation training for captains/ staff • Navigation equipment • Climate proofed ship designs
Heavy rainfall	Medium	High	• Interruption of repair/painting activities • Accidents with electrical appliances	• Dry dock • Fixed shed • Safety training
River flooding	High	Low	• Interruption of cargo service • Interruption of repair/painting activities • Accidents/safety challenges • Navigation problems	• Navigation training for captains/ staff • Navigation equipment • Climate proofed ship designs
Salt water intrusion	High	Medium	• Faster corrosion and damage of ships and equipment	• Improved anti corrosive paints/ hardener coat • Equipment Maintenance training
Siltation	High	High	• Slipping problems • Navigation problems • Half cargo loading	• Hydraulic structures/water jet pumps

identified. This was discussed in meetings with the employees responsible for the challenges that were identified, including the chief engineer, the foremen for welding, painting and ship design, and the accountant.

For instance, in order to cope with rising temperatures in the **'location and building'** impact area, different shading constructions (e.g., large roof, small shade installation for materials) could be installed that also provide protection from rainfall. A roof could be combined with the setting up of PV cells reducing the company's dependence on grid power. In terms of the **'processes'** impact area, navigation challenges in rough weather could be improved by installing adequate navigation equipment**,** thereby lowering the risk of accidents and decreasing the frequency of interruptions to cargo services. The improved equipment also enables the company to identify and use optimized navigation routes and to ensure its compliance with national and international existing and future regulations. Improved navigation is likely to contribute to a more reliable on-time service. The use of new navigational equipment requires training the staff in navigation. This could also include training in changing weather patterns and the resulting risks.

Regarding opportunities, the assessment identified several services and products for new markets for which demand might increase, such as new navigation equipment, more durable marine paint or maintenance services required due to rust.

Third step: selection of adaptation measures

Based on the insights gained through cooperative analysis of the risks and opportunities, several adaptation options were identified and clustered with the aid of a risk assessment

Table 4: New business opportunities for M/S Rocky Dockyard (GIZ PSACC, 2017a)

Climate phenomenon	Target market/ customers	Expected market changes	Timing/urgency	Potential product/ service/ innovation	Type of product/service/ innovation			Challenges and potential solutions
					Has properties with reduced climate vulnerability	Facilitates adaptation	Other	
Extreme weather condition/Heavy rain	Ship owners	Demand of navigation equipment may rise	Already noticeable and continuous growth is expected	Radar, echo sounder, signal light, modern GPS system, installation of signal lights		X		Increased expenditure for vessel owners, technical expertise to operate the equipment

matrix setting priorities for the probability and amount of negative effects on the business.

On this structured basis, M/S Rocky Dockyard selected the following adaptation measures as priorities:

- Navigation training and navigation equipment to improve navigation abilities in rough weather and silted waterways;
- Improved anti-corrosive paint to increase the lifetime of ships;
- Energy-efficiency training in the use of electrical devices to save energy and lower energy dependency;
- Use of water jets and/or water pumps to ensure continued usability of navigation channels for the vessels.

For each of these priorities, a **cost benefit analysis (CBA)** was conducted. The company decided finally to focus on **'Navigation training and navigation equipment'** because this can increase the frequency of ships in service, while also ensuring safe navigation. The CBA also showed that the other measures were not as feasible and effective for Rocky Dockyard because improved anti-corrosive paint was not easily available, increasing energy efficiency further would entail significant investment, while constructions such as water jets were frequently destroyed by ships entering or leaving the harbour.

Fourth step: adaptation strategy

The training in navigation was developed to provide knowledge on meteorology, seamanship and navigation, as well as hands-on training on relevant navigation equipment under changing river conditions due to climate change phenomena such as heavy rainfall, storms and droughts. The training was prepared in association with the Deck Engineers Personal Training Centre (DEPTC), a training centre for captains and deck personnel from Bangladesh, and conducted in cooperation with the International Maritime Training Academy (IMTA). More than thirty captains of the Khulna region were trained in the use of the relevant navigation equipment, installed on a training boat provided by Rocky Dockyard. It is also planned to integrate the navigation training into the regular training schedule of the DEPTC and IMTA in order to anchor water transport-related climate change adaptation sustainably in Bangladesh.

4.2 Morocco : Nouvelle AVEIRO Maroc, Agadir

AVEIRO is a fish-processing company founded in 1946 and based in Agadir in the semi-arid region of Souss-Massa. The cannery factory is located twenty kilometres from the Atlantic coast in the Ait Melloul industrial zone. Around 600,000 cans are produced every day and marketed under three different labels. As the company counts three hundred

Table 5: Climate change impacts and related adaptation measures for AVEIRO (GIZ PSACC, 2017a)

Climate phenomena and impacts	Climate risks	Identified adaptation measures
Heavy and more frequent rain	• Facilities and premises flooded • Stocks of finished products under water • Disruption of logistics and supply chain (blocked roads during flooding)	• Adapting parts of the company infrastructures to avoid flooding (e.g. pavement) • Integrating flood barriers • Alternative supply routes and weather alert system to inform fishers of extreme events • Strategic inventorial management
Increased temperatures and more frequent heat waves	• Power cuts and overheating of fridges during heatwaves • Deterioration of working conditions and decrease in productivity during heat waves • Degradation of fish quality	• New insulation materials for fridges • Renewable energy to reduce the company's dependence on the grid • Include green spaces at the company premises • Optimise indoor ventilation
Water stress	• Disruption in water supply because of decreasing groundwater levels • Increased water prices	• Integrating water efficient measures in the production processes (e.g. filter for gutting machines, water recycling, etc.) • Sustainable water management system (e.g. monitoring system etc.) • Awareness raising/training of employees on sustainable water usage • Collective rainwater collection system in the industrial park
Changing physical – chemical patterns of oceans (e.g. increased temperatures of oceans, acidification)	• Decrease in available fish stocks and quality • Less variety of fish species	• Construction of a congelation factory close to the fish suppliers • Increase imports and supplier diversification • Investment in R&D for product diversification for canned food • Engagement in marine ecosystem preservation
Other cross-cutting and climate change related risks		**Identified adaptation measures**
• Stricter regulations on environmental and climate-related issues • Higher constraints and requirements from international clients and banks on climate and environmental issues		• Better monitoring of environmental regulations • Development of a CSR strategy • Engagement in further eco-friendly labels

full-time employees, it was considered to be of medium size according to the Moroccan classification.

During awareness-raising workshops on climate change adaptation in the industrial zone of Ait Melloul, a business competition for the Climate Expert risk assessment was launched, and AVEIRO was selected by ADIZIA, which manages the Ait Melloul industrial zone. For the following steps, the same methodology and assessment grids as described above were used.

In the case of AVEIRO, the CEO of the company also participated in the launch discussion and final presentation in order to endorse the process and to decide on final investments.

First step: climate change impacts:

Information on climate phenomena and climate impacts on the region was provided by the Moroccan Meteorological Institute (Météo Maroc) and l'Agence de Bassin Hydraulique (ABH) from the company, and from the project. Morocco, and particularly the Souss-Massa as a semi-arid coastal region, are being affected by an increase in average temperatures, changing rainfall patterns and sea level rises. Extreme weather events, such as droughts, flooding and heat waves, have become more and more frequent and intense. The company has already experienced flooding of its premises and storage areas (impact area: building and location), delays and product damage in its supply chain because of impassable roads for transport (logistic and stocks) and a reduction of 5% in the productivity of

its employees (employees and community) during periods of high temperatures. Given that fish-processing is a very water-intensive production process, the increasing scarcity of water resources in the region is also putting business operations at risk, all the more since an increase in water prices is expected. Finally, the core business of the company is at risk in the long term, as the migration and decline of specific fish stocks is accelerating.

Second step: risks and opportunities

The results were discussed with different members of the management team, leading to adaptation measures related to several climate phenomena and impacts:

As opportunities, AVEIRO identified decreased production costs through investments in water- and energy-efficiency measures. New innovative products could also be developed in response to climate change, such as new types of cans for different fish species or fruit and vegetables.

Third step: – selection of adaptation measures

Based on the risk assessment matrix, three adaptation priorities were seen as most relevant and were thus selected:

- Water-efficiency measures, e.g., investment in a water-recycling system for the fish-cleaning process
- Engagement in marine ecosystem preservation
- Professional monitoring of environmental regulations

Fourth step: adaptation strategy

During this process, it was considered important to reassure the public authorities that implementing the adaptation measures would avoid maladaptation. AVEIRO, for instance, is cooperating with universities and public authorities in this regard. The regional environmental authority Observatoire Régional de L'Environnement au Maroc (OREDD) was also partially involved in the process.

AVEIRO decided to integrate the climate risk approach into its general risk-management system and to promote this approach among other members of the industrial zone. Still ongoing is the implementation of adaptation measures that are interlinked with the risk of supply systems, especially water recycling. AVEIRO was selected as a 'best practice' in climate change adaptation in Morocco for the 'Confédération Générale des Entreprises du Maroc (CGEM)', Morocco's largest business association.

5. Challenges and solutions / success factors

During the program's work with numerous companies and other private-sector stakeholders, several challenges and success factors were identified.

5.1 SMEs are heterogeneous and require individual support

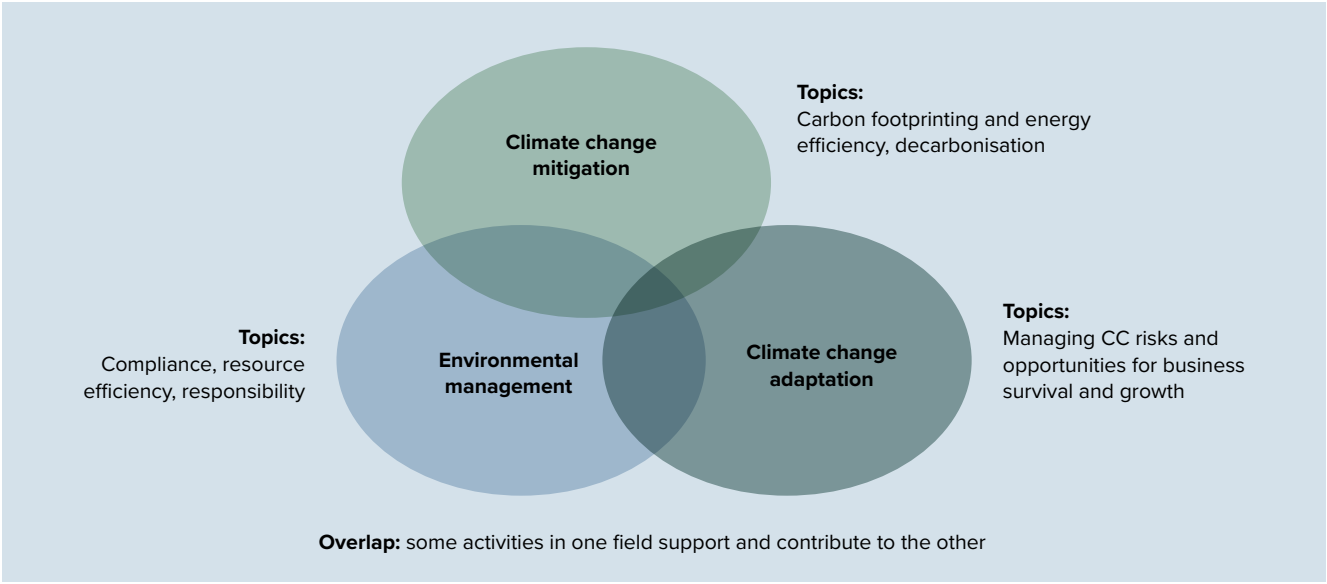
A key challenge for projects targeting SMEs across countries and sectors is the heterogeneity of this target group. The SME definition varies across countries and is usually defined by way of annual turnover, asset value and/or employees. For example, in Rwanda, SMEs are defined as companies with up to a hundred employees, while in Bangladesh SMEs may have up to 250 employees.

In addition to variability in national SME definitions, there is stark heterogeneity on the part of the enterprises they cover. For example, the SME category may include single entrepreneurs, family-run businesses with three staff members and companies with more than two hundred employees.[2] Service-oriented businesses are often very different from businesses in the industrial sectors. Moreover, SMEs also vary in respect of their management structures. While owner-led companies can take quick decisions, those with more complex ownership and/or management structures often react more slowly due to longer decision-making processes. Location and technology level are particularly important considerations for determining the risks resulting from climate change. Location directly influences exposure to certain climate risks (e.g., flooding), while for manufacturing companies a low level of technology means that work is labour-intensive, and therefore employee health and productivity considerations are important.

In **Morocco**, cooperating with larger companies was a successful approach, as they are well-structured and have access to relevant data. Risk management approaches have been integrated into their management strategies. In **Costa Rica**, smaller companies in the tourism sector have also shown great commitment because the owners are generally very active in developing their companies in a sustainable manner. This is partially due to the national focus on sustainable tourism.

[2] As the project worked through SME multiplier organisations, it focused on SMEs as nationally defined.

Figure 7. Relationships between mitigation, adaptation and environmental management (GIZ PSACC, 2017a)



5.2 SMEs are not always aware of the relevance of adaptation

While some of its impacts are already visible, many of the dynamics of climate change will emerge over the course of decades,[3] putting them beyond the planning horizons of SMEs. This makes it difficult for SMEs to see the interdependence between the changing climate and their operations. This may also explain why many SMEs only appreciate the need to prepare for climate change once they have been affected by a supposed climate change phenomenon, such as an extreme weather event. At the same time, many SMEs may decide on adaptation measures for already observable events without calling this adaptation. In these cases, a long-term perspective is often lacking, and stakeholder considerations are rarely taken into account, which can lead to 'maladaptation'. Hence, SMEs need to be made aware of how both extreme weather events and slow onset changes affect a company's premises, supplies, logistics, stakeholders and business environment within their planning horizons. Moreover, focusing not only on the negative effects of climate change but also on the potential benefits of adaptation (e.g., reduced variable operating costs due to improved energy efficiency) will incentivize managers to search actively for such opportunities. Awareness-raising is particularly important for the target group of SMEs, as they often focus on the immediate bottom line of their business and do not routinely assess medium- to longer-term trends as larger companies do.

For instance, in **Rwanda** almost all manufacturing companies participating in their sectoral awareness-raising workshop initially stated that they were not affected by climate change. However, after discussing climate risks during the workshop, they came to realize that the increased frequency of roadblocks due to landslides caused by heavy rains in recent years could indeed be related to climate change, and that they can be prepared for more frequent such events. This was mentioned as one of the biggest operational problems currently, causing considerable losses to almost all participating SMEs.

The following points considerably increased the SMEs' understanding of climate change adaptation:

A) Clear explanations of adaptation measures and their overlap with mitigation efforts and environmental management. Adaptation measures can assume a wide variety of forms, many of which are already known to SMEs. Many adaptation measures that seek to increase resource efficiency are linked either to mitigation or, more comprehensively, environmental management issues. Where considerations of pollution or harmful impacts play a role, there is an overlap with topics that have already

[3] Yet, once certain tipping points are reached, the impacts of climate change can very quickly become much stronger. Research on tipping points is essential for informing adaptation strategies.

been on the environmental management agenda for a long time. Therefore, many SME managers are already familiar with parts of the activity spectrum of adaptation, and this realization helps them understand the concept of adaptation. It is therefore recommended that climate risk management be included in general risk management systems.

B) Demonstrating the concept of climate-related business risks and the advantages of early action. As already pointed out above, testimonials and examples of best practice (by region and/or sector) are effective in demonstrating how business advantages can be achieved through strategic adaptation. Examples of best practice need to show how climate change impacts can influence income statements and balance sheets. Starting by analysing general business risks instead of climate risks in awareness-raising settings has also proved effective. In the case of **Morocco,** since 80% of the risks identified at an awareness-raising event were climate-relevant, private-sector representatives were greatly interested in learning more about climate change and adaptation. In fact, it is often the case that climate change exacerbates the existing pressure points on SMEs, including resource prices (water, energy, primary resources), value chain issues and stakeholder problems (including employees, neighbouring communities, NGOs).

C) Linking climate risks with past experiences. Once the concept of climate-related business risks is understood, it should be shown how climate change has actually affected the target group in the past. Relating past damage and costs to weather events or long-term climatic changes will make it easier for business managers to grasp the challenges that lie ahead.

D) Showcasing clear possibilities for action. It is also important to help companies understand which concrete adaptation measures can help them adapt to climate change. This is necessary, as it was found that many of the smaller companies consider climate change to a *force majeure* against which they cannot do anything individually. But SMEs do have the power to reduce their vulnerability through taking action. One of the most relevant products used during the PSACC project was an 'Adaptation Measures Catalogue' developed by the project that showcases adaptation measures for various climate change scenarios. For example, the development and implementation of several measures promoting resource efficiencies and disaster risk management are described in detail in this catalogue.

5.3 SMEs need to see their ownership in climate change

Many SME representatives stressed the importance of public-sector action with regard to climate change. Particularly preparation for and response to extreme weather events were cited by businesses at the beginning as examples of measures in the spheres of action of local, regional and national governments.

For example, a **Rwandan** company had repeatedly been affected by flooding of its premises, destroying stock and interrupting production during heavy rains. The company had requested local authorities several times to fix the flooding problem, as they considered the authorities responsible for an effective drainage system. After a risk assessment was conducted and discussed with the company's managers, they built a wall to prevent the water from entering the company premises, as they did not expect the municipality to act in the near future.

In **Morocco,** at the beginning of the project, discussions were held on whether climate change is man-made, on the differences between mitigation and adaptation, and on the responsibility of industrialized countries for climate change. These discussions were a necessary prerequisite for then shifting the focus to potential SME adaptation activities. To prepare this shift, concrete climate change impacts on companies were presented to SME representatives, who discussed risks and solutions from their own perspectives. Afterwards, public-sector representatives were requested to comment on these and to identify areas in which the SMEs could be supported.

5.4 SMEs often lack the necessary capacity to adapt

SMEs face several issues related to their capacity and available information that hinders them in adapting (apart from financial issues that will be elaborated on in the next section). The following methodologies and instruments were used to enhance SMEs' capacities to adapt:

A) Simplicity and business-mindedness of capacity-building activities. SMEs in developing countries and emerging economies generally face a 'skills gap', as skilled workers in these countries often prefer to work for larger and international companies or for the government, or to go abroad. In the PSACC program, this was evident in Rwanda and Bangladesh. This gap is even more pronounced for climate change-related issues, as climate change is a

relatively new and complex topic for SMEs, and specialized knowledge is required to assess the effects on a particular company. Lessons learnt throughout the PSACC project showed that, from the private sector's perspective, effective SME adaptation to climate change necessitates simple, business-relevant language and concepts to enable a clear understanding of what adaptation entails.

B) Advisory and consultant services that keep the SME perspective in mind. To initiate and implement an adaptation strategy, SMEs often need support from specialized experts, which is why the Climate Expert approach includes the training of consultants. The most important task of the consultant is to support the management in choosing viable adaptation measures. Experience has shown that it is helpful to focus first on low- and no-cost options in order to avoid implying that climate change adaptation is too costly for SMEs. Given that SMEs have a relatively short planning horizon, they will often prefer measures with short amortisation periods. For medium- to long-term measures, profitability must be clearly demonstrated. After the assessment has been completed, continued consultant support is helpful in identifying financing opportunities or implementing monitoring strategies.

C) Engaging with the right resource persons and management. Another important consideration relates to the selection of capacity-building and/or participants from within each company. In the experience of the project, both technical staff (e.g., the lead engineer) and managers (e.g., the owner, CEO or CFO) should be involved in making assessments of climate risks. While engineers often have the required technical expertise to identify a set of viable adaptation options, top management has the power to decide on managerial measures and initiate their implementation. The leader or CEO has to be involved from the beginning of the process in order to ensure high-level commitment right from the start.

D) Ensuring the availability of data. SMEs need to have access to reliable data in order to make sure that the costs and benefits of adaptation measures are calculated correctly and can serve as a reliable basis for making investment decisions. While internal data (e.g., on energy and water use) should be made available by those in charge of SMEs, external information (e.g., meteorological data and climate forecasts) can be obtained through peer exchange and consultation or collaboration with public institutions, such as meteorological stations.

5.5 SMEs often do not have sufficient access to finance for adaptation

After defining the most urgent climate change risks faced by an SME, the Climate Expert tool advises the development of an adaptation strategy for and by the SME. During the development, it often became clear that, though willing to confront climate risks, SMEs had difficulties in mobilizing the financial or staff resources to do so. This is of course partly due to the general difficulties that SMEs in developing countries and emerging economies face in accessing finance. However, with regard to climate change impacts, the situation was somewhat more complex.

The accompanied pilot companies in all four countries resorted to implementing those measures that incurred little or no financial cost. They were mostly financed out of their own means. One exception is **Costa Rica,** where FUNDECOOPERACIÒN, a local fund for sustainable development that grants credits combined with technical assistance to SMEs, integrated the Climate Expert approach into its loan appraisal process for their adaptation loan program. In another case, private equity finance was discussed as an option.

It proved helpful in the pilot countries to provide SMEs with an overview of existing financial instruments that can also be used for adaptation measures, as many were not aware of the available offer. For example, in **Costa Rica**, a wide range of credit lines are already available from public and private banks, as well as other financing institutions that target SMEs. Many of the credit lines finance resource efficiency and sustainable business practices, and they can be used for those adaptation measures that fit. But in a lot of other cases, public money (e.g. concessional loans) is still necessary to leverage private investment.

5.6 Reaching SMEs by up-scaling using private-sector multipliers

Adaptation support to SMEs needs to be provided individually because adaptation is highly company-specific. Yet improving the resilience of the SME sector necessitates a wide reach of support to adaptation. In order to reach a large number of SMEs, the project made its experiences and approaches available to different multiplier organizations, such as chambers of commerce, business associations,

training institutions for businesses, industrial park managers and NGOs that work with businesses. These multiplier organizations were enabled to use the Climate Expert approach, and were supported in advising their members and SMEs in how to adapt their strategies to climate change.

Some examples show the potential of integrating strong multiplier organisations. In **Bangladesh**, cooperating partners include the BIM Training Institute, which trains approximately a hundred enterprises a year in sustainable supply-chain management, including modules on adaptation. The Eco Tourism Chamber in **Costa Rica** (CANAECO) can mobilize 115 members in the tourism industry and is organizing several awareness-raising events and workshops, as well as Climate Expert assessments for their members. **Morocco**'s largest business association, the Confédération Générale des Entreprise du Maroc CGEM, has integrated climate resilience approaches on the national level into their regular program for their 33,000 company members. Industrial zones or parks also offer opportunities for up-scaling. In Morocco, the network of Eco Industrial Parks COZINE reaches approximately ten thousand companies. In **Rwanda**, the project partnered with ARCOS, a regional conservation organization with the mission to enhance biodiversity conservation and the sustainable management of natural resources. ARCOS already works with enterprises in strengthening their social and environmental responsibilities. ARCOS intends to enlarge its business network by focusing on the new area of 'adaptation'.

Multipliers for adaptation need to be carefully selected according to their ability to integrate adaptation as a concept into their agendas, as well as their dissemination and support capacities in providing their members with climate adaptation relevant information. It is recommended that those stakeholders with strong outreach potential and/or with a good reputation among business entities be selected.

On the level of national policy, Costa Rica and Morocco have already started to integrate the private-sector approaches that have been developed so far. The Climate Change Directive of the **Costa Rican** Ministry for Environment has invited the Steering Committee that supervised the Climate Expert approach to be a representative body for the tourism industry and to participate in the national NAP process. Likewise, the PSACC project's experiences are being fed into the National Competence Center for climate change mitigation and adaptation in **Morocco** (4C Morocco). 4C was established in order to support Morocco in implementing and further developing its national climate policy and its national Green Investment Plan by integrating the public and private sectors, as well as civil-society and research organizations. In addition, and also on the regional level, a strong level of commitment was achieved in respect of linking the activities in the Ait Melloul industrial zone and the Regional Council. The developed action plan for climate change adaptation of the industrial zone has been integrated into the Regional Council's relevant regional programs.

6. Conclusions and further suggestions

The project's experiences, gathered through pilot activities in various countries and sectors, allow conclusions to be drawn on the challenges and success factors for increasing awareness and building capacity for climate change adaptation among SMEs. The following points have been found valid across countries and sectors and can serve as the basis for developing a more comprehensive approach to engaging SMEs in adaptation to climate change.

In all pilot countries, it was important to have evidence of successful SME adaptation (e.g., by way of case studies) to demonstrate the benefits of adaptation to SMEs. In order to reach a larger number of SMEs across various countries and sectors, more case studies of successful adaptation need to be developed and made accessible to companies. These case studies should include financial metrics and decision-making tools, such as cost–benefit analyses. The demonstration of business and financial benefits proved to be important in engaging with and motivating SMEs to act on adaptation.

Even though identifying the most suitable adaptation measures is highly individual and based on a company's location, size, adaptive capacity and numerous other factors, SMEs benefit from cooperation and from exchanging learning experiences on adaptation with their peers and associations. Showcasing a wide range of adaptation measures, the project developed a catalogue of sample adaptation measures. The measures in this catalogue were deduced from real assessments. The catalogue should be expanded in the light of further experiences with successful adaptation.

One of the key hindrances for SMEs in implementing adaptation measures is access to finance. A comprehensive

approach to private-sector adaptation should therefore include the financial sector in order to build awareness among financial institutions regarding the benefits of adaptation, including in respect of the SME's risk profile. In the medium to long terms, climate risk assessments and presentations of adaptation strategies could be integrated into the general risk assessment of loan appraisal processes in those countries and sectors where climate change vulnerability is high.

This approach has been developed for SMEs, but a simplified version can be used when working with micro-enterprises. The awareness-raising methodology would need to be adapted to reflect micro-enterprises' own needs and constraints, while the climate risk assessment may be more effective if applied to a geographical area or sector. In this way, the competencies and financial options of individual enterprises can be combined, thus jointly increasing resilience. This approach was tested by the program in Bangladesh for the light engineering sector.

Finally, the certification of climate risk assessments was an issue that came up in all four pilot countries when discussing a way forward. To increase the value of climate risk assessments for the private sector, it might be helpful to develop an official certification system for consultants and/or for SMEs. This certification could distinguish SMEs from their competitors, qualify the respective SME for specific financing programmes, or improve their prospects for finding finance, once they have demonstrably minimized their climate risks.

In all countries, dialogue with and the integration of key stakeholders was an important factor in the success and sustainability of the project's activities. Engaging with stakeholders not only raised their awareness but also created local 'ownership' of the topic and established cooperation among them. This strengthened their capacities to follow up project activities, while integrating these activities into their business strategies or service portfolios. This ensures that SME adaptation continues to be tackled in the project's pilot countries, thereby strengthening the sector's resilience against climate change.

These experiences made in several countries throughout a variety of different sectors, show important similarities and suggest that these insights will also hold true in other contexts and different countries all over the world.

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Developing a sustainable framework for SMEs to design, finance and implement suitable flood resilience measures in Mumbai, India

Abstract

This paper describes an operational and financial framework developed under the Admire project for small and medium enterprises (SMEs) to facilitate flood resilience efforts in urban areas of Mumbai. Private businesses in the city, particularly SMEs, face recurrent floods with alarming regularity that cause damage to physical infrastructure, the temporary closure of businesses and loss of productivity, resulting in huge losses each year. In addition, temporary measures undertaken by SMEs for flood protection are ineffective during heavy to extreme rainfall and create potential for maladaptation by pushing flood water into low-lying adjoining plots or roads. Given the threat of future climate change and worsening flood risk, long-term solutions are required to enhance the flood resilience of SMEs. Under this project, several structural and non-structural measures have been recommended for SMEs based on the field surveys. To help all flood-affected SMEs on industrial estates to implement the recommended measures, a robust operational and financial framework has been developed. Industrial estates can follow the steps in this framework in order to choose the most suitable adaptation measures for implementation. Challenges in designing the framework of this project and lessons learned from it are also discussed here to make it relevant and replicable for SMEs elsewhere.

1. Introduction

Recurrent flooding caused by heavy to extreme rainfall has adverse consequences in the form of extensive damage to public and private infrastructure, loss of property and disruption to economic and social activities. Households, large private-sector organizations, small and medium enterprises and retail businesses face increasing risks and multiple vulnerabilities due to the occurrence of flooding year after year. Future climate change is expected to exacerbate these risks by changing the intensity, frequency and duration of rainfall. In response to recurrent floods, private stakeholders like households and businesses undertake temporary measures, such as raising the surrounding plot levels, digging temporary drainage channels and constructing temporary flood barriers at the entrances to houses or business units. However, such measures are often locally designed, ad-hoc solutions that prove ineffective during heavy to extreme rainfall and, moreover, often lead to maladaptation from flood water being pushed into adjoining areas. Hence, there is a need to build a sustainable framework in which the private sector can plan, finance and implement suitable and effective adaptation measures with a view to enhancing long-term resilience and protecting itself from future climate risks.

UNEP DTU Partnership (UDP) and MP Ensystems Advisory have therefore initiated a project to develop a sustainable framework for private sector-financed flood-resilience efforts in Mumbai under the ADMIRE Programme.[1] The focus of the project is on managing flood risks from the private-sector perspective, specifically, the small and medium enterprises (SMEs) located in industrial estates in the city. The objective of the project is to create a sustainable and replicable operational and financial framework for private sector-funded resilience measures in the context of recurrent flooding, whereby SMEs located in industrial estates participate in planning, designing, financing and implementing measures for flood-risk mitigation. The long-term development objective is to increase the adaptation capacity of SMEs to manage enhanced flood risks related to climate change.

Although SMEs constitute an important part of the regional economy and provide employment opportunities to its semi-skilled and unskilled workforce, there is no comprehensive database available on either industrial estates or SME units, which are neglected in formal loss assessments following flooding or other disasters. Neither the local government nor industry associations have tried to assess the impacts of flooding on SMEs in Mumbai, nor to suggest long-term counter-measures. Therefore, to identify the physical, economic and social vulnerabilities of SMEs to recurrent floods and their own current response measures, L ward of Mumbai has been selected as the study area, and baseline data have been obtained through a primary survey of randomly selected SMEs on industrial estates. The baseline data have been used to capture the impacts of recurrent flooding and its associated costs for SMEs during annual flooding events. The measures SMEs currently undertake, whether individually or collectively through industrial estates, have temporary impacts on reducing flooding intensity but have proved to be ineffective when the rainfall is heavy or extreme and main water and drainage channels are blocked. The project team, which includes structural and water experts, have studied technical parameters in the surveyed industrial estates and have recommended long-term structural and non-structural measures to deal with current and future flood risks. Various financing options to facilitate implementation of these measures have also been identified. The process of planning, designing and financing suitable adaptation measures has been facilitated by means of an operational and financial framework that is meant to guide SMEs through a step-wise approach to initiating, participating and implementing flood resilience measures suitable for the industrial estates on which they are located.

This paper presents this model operational and financial framework, developed for SMEs located in industrial estates in Mumbai. Structural and non-structural adaptation measures designed for SMEs will be discussed here along with the potential financing options for implementation. The outline of the paper is as follows. Section 2 describes the vulnerability of SMEs to recurrent flooding in Mumbai and also discusses current response measures and their effectiveness in providing flood protection. Section 3 provides a brief description of the study area of L ward in Mumbai, where a primary survey of flood-affected industrial estates has been conducted. The model's operational and financial framework is presented in Section 4, describing in detail the various steps in the model framework, including problem assessments, key parameters, structural and non-structural measures designed for SMEs based on these parameters,

[1] ADMIRE supports the development of implementable mitigation and adaptation actions with private-sector involvement and is being implemented by the UNEP DTU Partnership and UNOPS with funding support from the Danish Government. See http://www.admireproject.org

financing options and the road map for implementation. Lessons learned and reflections on the replicability of this approach are discussed in Section 5.

2. Vulnerability of SMEs to recurrent floods and current responses

Micro, small and medium enterprises (MSMEs) form an important part of the national and regional economy of most developing countries, including India. SMEs in India are defined under the Micro, Small and Medium Enterprises Development (MSMED) Act 2006 in terms of the total value of their investment in plant and machinery (GoI, 2016). There are about twenty product groups in the SME sector, including chemical products, basic metal industries, electrical machinery, rubber and plastic products, garments, leather products, paper products and printing, and transport equipment. SMEs play a critical role in employment generation, regional development, export promotion and the development of ancillary bases for large industries. Most SMEs in India operate from industrial estates, which are common areas housing a number of such units operating in similar or diverse businesses. SMEs on industrial estates may enjoy economies of scale in infrastructure facilities such as electricity, water, transport, banking, post offices and the provision of canteens

Compared to large private-sector businesses, SMEs are more vulnerable to natural hazards due to their constraints in terms of resources, knowledge and planning and gaps in experience. The impacts of such hazards affect their physical infrastructure, production processes and supply chains, their employees and neighbouring communities, and also the demand for their products and their ability to access finance (KPMG, 2016). Floods are a growing challenge for small businesses around the world. For instance, the 2015 floods in the Calder Valley in the United Kingdom cost nearly 47 million Euros in terms of direct and indirect losses to SME units and 170 million Euros in their total economic impact on the local economy (Sakai, Holdsworth, & Curry, 2016). The 2011 floods in Bangkok caused losses to the private sector to the tune of USD 40.82 billion (GIZ, 2014). The worst affected during these floods were the SME units, which had to suspend production for several weeks, having serious impacts on the regional and global supply chains (Avory, Cameron, E., Erickson, C., & Fresia, 2015). Similarly, unprecedented floods in the city of Chennai in India in November 2015 caused extensive damage to SMEs and industrial estates. The most conservative estimates put the losses at around 17 billion Indian rupees (INR) in the two weeks of peak flooding (KPMG, 2016). There were serious impacts on SMEs in terms of infrastructure damage, the disruption of production cycles, continuity of businesses and impacts on the health and safety of employees. India is one of the most vulnerable countries to climate change, and SMEs are particularly vulnerable, as they often lack the technical, financial and human resources to assess, monitor and adapt to climate risks. As the capacity to deal with financial losses or business disruption is relatively low, climate change impacts can even threaten SMEs' very survival as businesses (GIZ, 2013).

In Mumbai, flooding is a chronic and recurrent problem that causes extensive damage to infrastructure, loss of property and livelihoods, and disruption to economic and social activities. There are about 30,000 SME units operating in the city and employing about 200,000 people according to anecdotal information and the available private databases for Mumbai. The extreme rainfall of 944 mm falling in 24 hours on July 26, 2005 damaged property and assets worth millions of dollars. Estimates suggest that the losses from direct and tangible damage were in the tune of USD 1.24 billion, of which SMEs suffered losses of USD 149 million (Patankar & Patwardhan, 2014). Flooding continues to be a chronic and recurrent problem in the city due to tidal variations, flat gradients and mud flats causing excessive siltation (MCGM, 2014). Many low-lying and reclaimed areas are flooded, especially when heavy rains coincide with high tide or storm surges. Other important causes of flooding are man-made, including inappropriate levels of outfalls, the loss of holding ponds due to land development, increases in the run-off coefficient, and encroachments on drains and obstructions caused by utility lines being crossed (MCGM, 2014). Industrial estates located near chronic flooding spots experience recurrent flooding at least two or three times every year, and SMEs continue to bear the costs of these floods.

3. Study area: L ward of Mumbai

To understand the impacts on SMEs in terms of losses and damage from recurrent floods and to evaluate current response measures, L ward of Mumbai was selected as the study area. This ward represents a typical mixed land-use area in the city, one that is prone to chronic flooding every year during the monsoon season from June to September. L ward has many chronic flooding spots, and SMEs are located near most of them. Among these spots, five locations were

selected to conduct questionnaire-based surveys among SMEs to gather baseline information and understand SME's vulnerability to flooding. SMEs, both in cooperative societies[2] and on individually owned industrial estates,[3] were covered by the primary survey.

The survey of 100 SMEs and interviews with fifteen industrial estates suggest that more than half of SMEs experience flooding three to four times every year during the rainy season and that he average depth of flooding is one to two feet. During very heavy rainfall (>120 mm per day), the flooding depth goes up to three to four feet. Almost all SMEs reported extensive damage to physical structure or equipment and products during flooding events. Using this information, as well as relevant assumptions, annual damage costs for SMEs in Mumbai have been extrapolated to INR 74.5 million (USD 1.13 million). These costs include damage to physical infrastructure, equipment and products, and emergency expenses during floods. Besides these damage costs, there are other losses due to suspended production, the absence of employees, the inconvenience of operating from flooded premises and health impacts. Many of these costs cannot easily be monetized, but they would contribute substantially to the total losses caused by floods. Expenditure on repairs and recovery has to be self-financed by the SME units themselves, as 97% of respondents do not have any flood insurance. More than 50% of SMEs have to take out insurance against fire and theft because the commercial banks that provide them with loans for machinery or business expenses insist of this. However, they do not opt for multi-hazard insurance schemes that include flood insurance, as such schemes invite higher premiums, and the process of claims settlement is very complicated.

Given their exposure to recurrent flooding, SMEs and industrial estates have implemented certain temporary measures. Their response varies depending upon the size of the business, flooding experiences, knowledge of flood management measures and ownership of the industrial estate. Among locally designed temporary measures are installing dewatering pumps inside workshops, elevating machinery and equipment on to platforms, constructing temporary flood barriers (bricks and cement blocks) at entrances and constructing temporary drainage channels. However, these measures are not helpful during heavy rainfall events when dewatering pumps are submerged and temporary barriers do not offer enough protection against rising flood waters. There are restrictions on elevating machinery and equipment, as ceiling heights in most units are not sufficient to permit such elevation. Often industrial estates pump out the flood water and push it into low-lying adjoining plots or roads through temporary drainage channels, thus creating the risk of maladaptation.

SME owners and cooperative society officials shared details of how their industrial estates suffer year after year and how temporary measures have not worked for them. Over the past two decades, the height of the adjoining road has increased with concretization. Sometimes this increase in height is considerable, and estates are now four to five feet below these roads. Changes in the heights of adjoining roads or plots have ultimately changed the direction of rainwater run-offs, thus affecting the drainage pattern of industrial estates connected to the municipal storm-water drainage network. Many estates also have to deal with water springing up from under the flooring at their units (workshops) throughout the rainy season and sometimes even beyond. In addition, solid waste management across the city is in a poor state due to inadequate infrastructure, irresponsible practices of waste disposal carried out by citizens, the scarcity of land, poor waste collection systems and inefficient technology. The solid waste is not collected regularly from industrial premises by the municipal authority, causing the internal drains to choke and further aggravating the problem of flooding. Also, the nearby slum-dwellers throw plastic waste on to the streets which flows towards the drains, choking them during intense rainfall and creating a situation of intense flooding in the area. Against this backdrop, there is a clear need to design and implement effective long-term adaptation measures to help businesses deal with current as well as future flooding risks due to climate change.

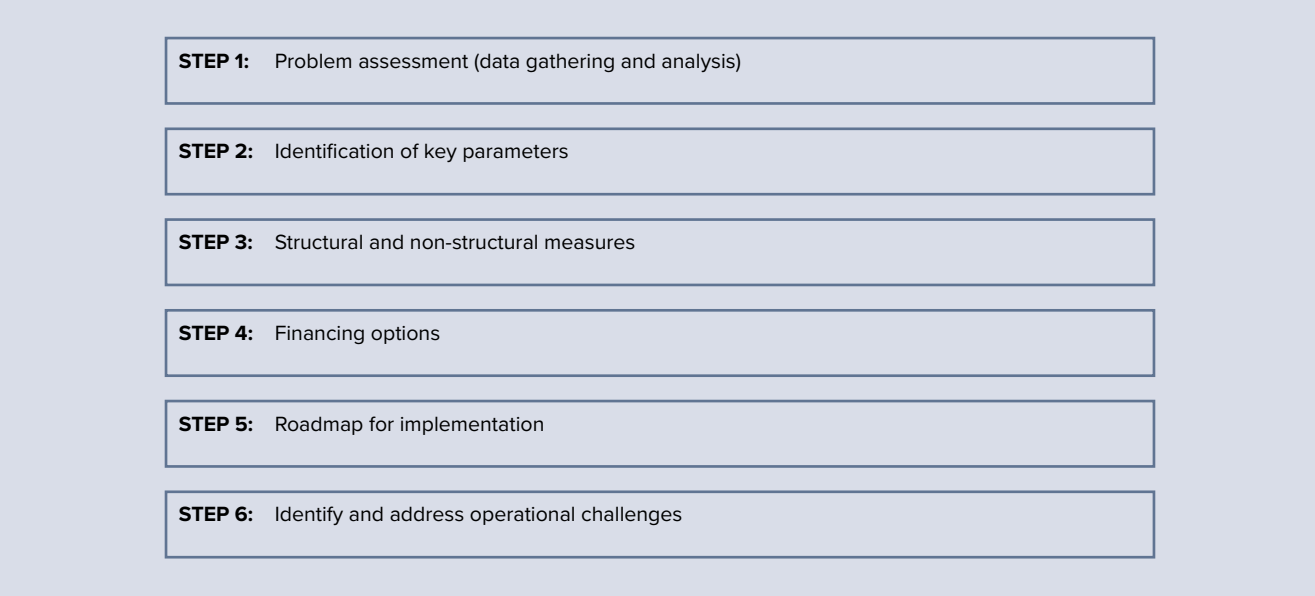
4. A sustainable framework for flood resilience

To facilitate the flood-resilience efforts of SMEs in Mumbai, this paper presents a sustainable and replicable operational and financial framework for private sector-funded resilience measures. This framework is expected

[2] A cooperative society is a registered body under the Maharashtra Cooperative Societies Act 1960, where SMEs located on an industrial estate form the society and become members of it. Here, individual SMEs own the premises from which they operate, and ownership of the industrial estate is vested in their cooperative society. The society forms a committee of elected officials from among its members to facilitate the day-to-day maintenance of its premises and resolve disputes among its members. Member SMEs make annual contributions to the cooperative society for performing various functions.

[3] A few industrial estates are not owned by SMEs collectively as a cooperative society, but by individuals. They rent premises to different SME units, but retain control over the ownership and maintenance of such industrial estates.

Figure 1: Steps in the operational and financial framework



to help SMEs (through their industrial estates) to plan, design, finance and implement adaptation measures. The **operational framework** provides step-by-step guidelines for industrial estates to identify, plan, finance and implement suitable adaptation measures. The framework identifies data requirements, technical parameters and indicative structural and non-structural measures to help in making industrial estates flood-resilient. The **financial framework** describes the various financial options available to industrial estates to implement the chosen adaptation measures. This framework can be used by individual industrial estate owners, cooperative societies in industrial estates, structural and design consultants and policy-makers to push for private-sector engagement in adaptation to flooding. Six steps have been designed within the operational and financial framework, as shown in Figure 1. Each of these steps is also described in detail in the following sub-sections.

Industrial estate officials should follow each of these steps carefully to implement the framework carefully. The industrial estates' cooperative societies are administered and managed by elected management committees generally consisting of a chairman, secretary and treasurer, themselves SME owners on the same industrial estate. The committee also appoints estate managers and other support staff to carry out the regular maintenance work of the estate. After due consultations with other SME owner-members, the committee officials and their appointed staff can use the steps outlined in the framework to implement the required measures.

This model operational and financial framework has a good replicability potential and can be used in different settings and contexts to achieve flood resilience. The model framework has been prepared by drawing on generic parameters and the identification of common problems on industrial estates across Mumbai and other flood-prone locations. The generic parameters are used to determine the mixture of structural and non-structural measures that will be required to achieve the desired level of protection from floods. This framework can, therefore, be used by SMEs and industrial estates in Mumbai and elsewhere to input the required values into the framework and customize the associated measures for themselves.

4.1 Problem assessment

The first step in designing suitable flood resilience measures is to assess the nature of the recurrent flooding and associated impacts on the industrial estate. This helps the estate choose the right measures to reduce these impacts. Detailed analysis of impacts also helps in assessing how the costs of the chosen measures will weigh against the potential benefits in terms of reduced losses and damage from flooding. Industrial estate cooperative society officials

can undertake problem assessments that include collecting and analyzing information pertaining to the frequency, duration and depth of flooding on industrial estates, the types of losses and damage and their financial valuation, current response measures and their effectiveness. Estate managers and other staff appointed by the committee can help in carrying out this assessment. In the case of industrial estates owned by individual owners or landlords, the owners themselves need to obtain this information from the SME units to whom they have rented out space.

In order to gather all the relevant information, SME units (at least 20% of SMEs in the estate) can be selected randomly and data obtained on total annual losses due to floods, the possible causes of frequent flooding, current measures and their effectiveness. This would help further in estimating different types of losses, such as damage to physical structures (flooring, walls, windows, etc.), infrastructure (air conditioning and electrical systems, communication systems), losses due to suspension of production and losses of productivity due to the absence of employees from work during flooding events. Information gathered at this stage is critical in order to identify suitable measures to address specific flood-related issues effectively and help in reducing losses and damage.

As regards current impacts and their costs, SMEs are able to give rough estimates of the financial losses from damage to physical infrastructure, machinery and inventory. However, intangible losses like worker absences, interruptions to power supply, business losses due to the time taken to reopen the business and health impacts are not included in their overall perceptions and assessments of risk. The problem assessment stage of the framework will bring out both the tangible and intangible impacts, thus enabling a valid case to be made for designing and implementing long-term solutions for flood protection. It is also apparent from surveys and interviews with SME units and industrial estates that they do not want to opt for flood insurance as a measure of risk protection due to the complicated paperwork and time-consuming procedures involved in making claims. They would rather take steps on their own for flood protection than invest in flooding insurance. SMEs also have deep distrust of local government's ability to deliver essential services like flood management. They would not be willing to pay any additional charges to the local authorities, even if they are guaranteed effective flood management measures. Hence, industrial estates need to focus on designing suitable solutions for building flood resilience on their own.

4.2 Identification of key parameters

Once the nature of recurrent flooding and associated impacts on the industrial estate have been identified, certain parameters have to be estimated for each industrial estate to help it design adaptation measures. The following parameters have been identified as important while designing suitable measures for flood protection:

- *Rainfall intensity.* This parameter decides how much water accumulates per minute on the industrial premises and how varying rainfall intensities lead to more or less water accumulation. The observed rainfall intensity in Mumbai generally varies from 20 mm/hour to 50 mm/hour. Measures need to be identified and designed to counter estimated water accumulation4 on individual premises.
- *Height of the estate in relation to surrounding plots.* Most industrial estates in Mumbai are 25-35 years old and have seen the heights of surrounding plots and adjoining roads increase compared to their own plots. This makes their plots low-lying compared to surrounding areas and hence more vulnerable to flooding.
- *Total plot area and external plot area (excluding built-up area of SMEs).* This helps in determining the technical requirements in respect of length, width, diameter, capacity, etc. for the recommended structural measures.
- *Connection with the municipal storm-water drainage network.* Connecting the industrial estate to the municipal storm-water drainage network makes it possible to release excess water that has accumulated on the premises into this network. However, if the municipal drains are blocked with garbage and silt, water will be retained on the industrial premises. Structural measures will, therefore, have to be designed that take into account whether or not the premises are connected and whether excess floodwater can be released into such drains.
- *Distance from the municipal storm-water drain.* This is another important parameter to determine the design of any measure with the potential to remove excess flood water from industrial estates and release it into the municipal storm water drains.

[4] Water accumulation per hour (cubic meters/hour) = [(Rainfall intensity mm/hr)/1000]*(plot area in sq. meters) and water accumulation per minute (liters per minute) = [(water accumulation in cubic meters/hour)/60] * 1000.

Table 1. Recommended structural measures

Measure	Description	Technical requirements	Approx. fixed and operating Costs
Cut-off channel at threshold	• Type of floor drain containing a channel shaped body used for the evacuation of surface water • Acts as a barrier to the flowing water entering the low-lying areas	• Channel size with specific width and depth • Precast RCC cover of specific thickness with drain holes	• INR 400,000 (USD 6061) fixed cost • Maintenance not required for next ten years
Planned surface drainage and SWD drains	• Constructing surface drainage and SWD drains on the premises to remove the excess water in the area	• Channel size with specific width and depth • Precast RCC cover of specific thickness with drain holes • Adjusting surface slopes where required	• INR 8,500,000 (USD 128,788) fixed cost • Maintenance not required for next ten years
Sump tank	• Capacity storage of approximately 100,000 liters in a concrete water tank below ground	• Specific diameter and height	• INR 1,600,000 (USD 24,242) fixed cost • No maintenance, as it is a concrete tank
Dewatering ring wells and dewatering pumps	• Dewatering well using cement concrete rings in accordance with the technical requirements • Specific number of rings to be placed one on top of the other after excavation • Gap between two rings not to be sealed to facilitate sub-surface ground water entering the dewatering well even during dry season • Pumping water in the well using the dewatering pump would help to keep groundwater at a lower level so that no spring effect occurs on the ground floors of industrial sites	• Rings of specific diameter and depth • Total number of rings • Dewatering pump with specific capacity measured in liters per minute	• INR 1,000,000 (USD 15,152) of fixed cost • NR 5,000 (USD 76) for overhauling of pump annually
Ground water cut-off walls	• Contaminated ground water can cause damage to building foundations, load-bearing columns etc. • Infiltration of sub-surface water from surrounding areas, e.g. sea front, beach areas, or nullahs (urban streams formed due to rainwater flow, or overflow of lakes during monsoon, carrying wastes, both solid and liquid, into industrial areas) • Construct a retaining wall between the source of seepage or infiltration and the site of ultimate damage	• High-density polyethylene (HDPE) liner and gravels inside to fill the hollow part	• INR 100,000 (USD 1,515) fixed cost • No maintenance required
Recharging pit	• Recharging pit comprising honeycomb brick walls, interfaced with existing bore-well through micro-tunneling • When water fills in this pit and starts rising, it will flow through the micro-tunnel into the bore-well • Using submersible pumps, water from bore-well can be drawn to use for industrial purposes • The water-holding capacity of this filtration pit would be about 10,000 liters	• Specific diameter and depth	• INR 50,000 for one recharging pit as fixed cost • Maintenance INR 2,500 annually

4.3 Recommended measures

Based on the above parameters and appropriate assumptions about costs, innovative structural measures have been designed and cost estimates prepared, as seen in Table 1. Each measure has been described in detail along with its associated technical requirements. All these measures have a lifetime of 25 years. The fixed and operating costs for each measure are approximate values estimated for assumed average values for different parameters. These costs were arrived at by using two representative industrial estates as case studies. The design of these measures incorporates context- and location-specific changes. By changing the input values of all the parameters, industrial estates can customize recommended structural measures, alone or in

Table 2. Recommended non-structural measures

Measure	Description	Approximate fixed and operating costs
Early-warning system	A tipping bucket rain-gauge with a sensor connected to the computer will collect data every fifteen minutes.	• INR 40,000 (USD 600) fixed cost • INR 2,000 (USD 30) for annual maintenance
Emergency planning and SOP	Standard Operating Protocol (SOP) guides to every SME unit and flyers with immediate steps that should be taken, installed.	• INR 25,000 (USD 375) fixed cost
Solid Waste Management	Housekeeping will take care of waste on a daily basis; only dustbins, gloves and other essentials need to be bought	• INR 40,000 (USD 600) fixed cost for equipment • INR 75000 (USD 1150) operating cost annually for housekeeping staff
Awareness building	600 brochures and workshop expenses in which a disaster management professional will carry out the session	• INR 15,000 (USD 225) fixed cost

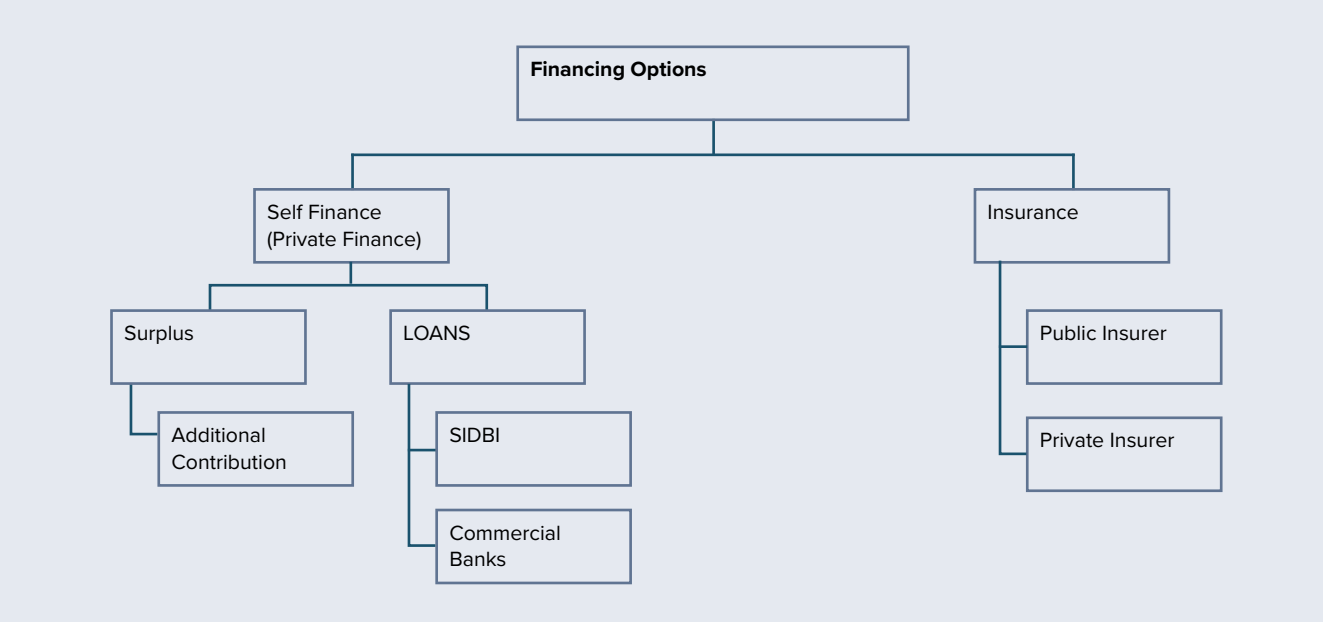
combination, to build flood resilience. Estate committees can seek technical inputs from structural consultants or storm-water experts in order to make suitable changes in the design of the suggested measures. These measures can also be implemented in a phased manner to spread the total investment over two or more financial years. There is no particular sequence to be followed in implementing these measures, and priorities can be decided on the basis of the nature and intensity of the flooding inside the premises. Although there are no direct or indirect financial incentives for SMEs to implement long-term adaptation measures, the stream of benefits estimated through the model framework can provide a convincing argument that industrial estate committees can use to seek their members' approval to invest in such measures.

Besides structural measures to help SMEs and industrial estates protect their premises from flood risks now and in future, non-structural measures like creating awareness among SMEs about disaster management, the development of early warning systems, emergency planning and better solid waste management will have a direct or indirect bearing on how effectively industrial estates deal with flooding risks. These measures will complement the use of structural measures and add to their overall effectiveness in flood protection. Table 2 below shows non-structural measures along with tentative costs, based on the survey of two representative industrial estates used as case studies. These costs will vary according to the requirements of each estate. There is also no particular sequence in which these measures need to be implemented by the industrial estate. However, once all these measures are implemented, they will help the estate committee to deal with recurrent floods more effectively.

SME owners and their society representatives are vaguely aware that climate change might bring about variations in rainfall patterns in future or that sea level rises might generate more floods. However, they have not thought of the impacts of such changes on their businesses and what measures they might be able to undertake today to adapt to the changing risks of tomorrow. Thus, awareness is a barrier that needs to be overcome to encourage more industrial estates to adopt long-term adaptation measures.

To help industrial estate committees design context-specific measures, as part of the project an Excel-based toolkit has been created to include all the measures, their technical specifications and tentative costs. The user, whether estate owner, committee official or consultant working with them, can input the values of the relevant parameters as described in section 4.2, along with basic information about the industrial estate. In the same spreadsheet, the user can then select which structural and non-structural measures the industrial estate would choose to implement. The choice of measures depends on what existing measures the estate has implemented, the funding the committee would be ready to invest and the desired level of protection from flooding the estate would like to achieve. The toolkit also allows changes to be made to the input values and choice of measures to see how the costs and benefits would change when different combinations of measures are to be implemented. The cost-

Figure 2. Potential financing options for implementing adaptation measures



benefit analysis in the toolkit also provides a summary of the total investment outlays, the net present values and the payback periods for different combinations of structural and non-structural measures. Users can then decide the most suitable combinations of measures and also plan phase-wise implementation if desired.

4.4 Financing options

Implementation of structural and non-structural measures will require initial investment outlays. Industrial estates are suggested as potential financing options, as shown in Figure 2 below. Industrial estates can self-finance the costs of the selected measures by using surpluses from their annual maintenance budgets. If these surpluses are insufficient, measures can also be financed by pooling extra contributions from individual SME units, which might be divided into monthly instalments. If the funds required to finance the structural and non-structural measures exceed the budget available within an industrial estate, there is the option of approaching either the Small Industrial Development Bank of India (SIDBI) or any commercial or co-operative bank for a loan. SIDBI is the principal financial institution for the promotion, financing and development of SMEs in India and offers various packages to SMEs to support their growth. The package suitable for upgrading existing infrastructure is called 'Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises', which can be tailored to suit the requirements of industrial estates. In addition, some commercial banks offer loans to SMEs at an interest rate ranging from 10.85% to 15.99% in the current scenario. The amount of loan ranges from INR 50,000 to INR 10 Million, with loan periods of one to fifteen years. Even cooperative banks, where industrial estates normally hold their cooperative society accounts, can extend credit for structural measures to be implemented. Banks which hold large amounts of fixed deposits as the corpus funds of industrial estates can offer loans at competitive rates against the collateral offered by these deposits.

The last option suggested by the study is to opt for flood insurance for risk protection. The idea behind flood insurance is to use the money claimed for flood-related damage to implement flood-protection measures. Special flood insurance packages can be chosen by SMEs or their cooperative societies for protection against unforeseen high-intensity rainfall and resultant flooding. In respect of the existing insurance products available in the market, to cover floods as part of the insurance scheme, the insured entity has to choose a Standard Fire & Special Perils policy from either a public or private insurance company. The premium may vary depending upon what is covered, for example, the building, plant and machinery, furniture and fixtures, the compound etc. The insured entity will bear the annual premium. If the cooperative society opts for such insurance,

the annual premium will be equally distributed among all SME members and can be recovered along with their annual maintenance contributions.

There is immense potential to explore the business opportunity for the insurance sector among SMEs by offering customized flood and other climate risk insurance products and providing incentives in the form of lower premiums when adaptation measures are implemented to reduce flooding risks.

4.5 Implementation road map

Once measures have been chosen and financing options selected, SMEs need to create a road map for implementation, as indicated in the fifth step. This involves holding consultations with members of the industrial estate or cooperative society in order to obtain majority vote on the proposal, finalize budgets, raise funds through the chosen financing route, float tenders for the contract to implement the chosen structural measures and self-monitor the their effectiveness. Each of these steps is described below:

Consultation:

- Holding consultations with members of the industrial estate or cooperative society to obtain a majority vote on the proposal.
- The proposal will include estimates of the impacts of flooding on the estate, current measures, selected structural and non-structural adaptation measures and the costs associated with them.

Financing:

- Finalizing the budget after selecting the suitable adaptation measures to be implemented
- Raising loans if needed or using existing funds or extra contributions from SMEs

Implementation:

- Floating a tender to award contract for implementing structural measures
- Undertaking implementation and self-monitoring

4.6 Addressing operational challenges

In the final step, the potential challenges and risks faced by SMEs and industrial estates in implementing the framework are identified. The potential challenges that the SMEs and industrial estates have to overcome are as follows:

For SMEs:

- If SMEs are run from cooperative societies, ownership is collective, and decision-making is more effective. However, collective agreement in choosing and implementing measures has to be obtained.
- For estates owned by individual landlords, flood control measures may not be implemented effectively, as the owner may not want to invest in such measures.
- SMEs would have to account for the potentially higher contributions involved to finance the chosen measures.
- While the structural measures are being implemented, there might be temporary disruptions to logistical movements on the estate's premises.

For industrial estates:

- Unanimity among the members of an industrial estate is essential before choosing and investing in long-term adaptation measures.
- The absence of a pressure group or apex body to convince individual SME units to undertake flood-control measures can be a crucial barrier to their implementation.
- SME units need to be convinced about the potential benefits of undertaking such investments.
- Collecting additional funds from members will be required to finance adaptation measures.
- Monitoring is critical for the effective implementation of measures in order to enhance their benefits. Society officials must undertake take on the responsibility for this function.

5. Conclusion: replicability potential of the framework

This paper has presented a sustainable operational and financial framework for SME-funded resilience efforts to cope with recurrent floods in Mumbai. Under this framework, SMEs located in industrial estates actively participate in planning, designing, financing and implementing suitable adaptation measures. The long-term development objective is to increase the coping and adaptation capacity of SMEs to manage flood risks. Each of the steps outlined in the framework should be followed carefully by the industrial estate cooperative society officials and members, i.e. the SME owners themselves, to implement the selected measures effectively on their premises.

Most industrial estates surveyed in this study have operated for more than three decades in the city and have been experiencing worsening recurrent flooding. Hence, there is

a keen interest in investing in long-term flood-protection measures. Based on the project's interactions with SME units and representatives of industrial estates, it is evident that SMEs are willing to design and implement structural and non-structural solutions for flood protection once they are provided with the right mix of solutions and guidance on how to customize them for their own premises. However, these measures should be designed and implemented on the basis of the relevant technical support and careful consideration of the different parameters determining exposure to flooding. Hence, use of this operational and financial framework will be extremely useful in identifying long-term solutions.

However, there must be an institutional mechanism or policy push to promote flood resilience among small businesses and industrial estates. Industry associations can play an important role in creating awareness about how the model framework can be used by industrial estates, but a policy push on the part of the government in the form of incentives to new industrial estates or for the inclusion of flood resilience in building codes would help in improving the adoption of resilience-building measures by the private sector.

The model's operational and financial framework and accompanying Excel toolkit have good replicability potential and can be used in different settings and contexts to achieve flood resilience. The model framework has been prepared by using generic parameters and drawing on common problems at industrial estates across Mumbai and other flood-prone locations. The generic parameters determine the mix of structural and non-structural measures that would be required to achieve the desired level of flood protection. Hence, this framework can be used by SMEs and industrial estates in Mumbai and elsewhere to input the required values into it and customize the measures for themselves.

The design of the toolkit also provides good scope for customization and replicability, as it features a step-by-step guide on what values need to be entered into the system to estimate the costs and benefits of different measures. We also envisage the model framework and toolkit being of use beyond the requirements of SMEs and industrial estates. Housing societies and commercial complexes located in flood-prone areas facing recurrent floods can also use this framework to design measures for flood protection. The methodology for using the framework and toolkit remains the same even in the case of these users.

This framework elevates this study beyond just providing generic prescriptions for flood management to describe actual design and financing options for the implementation of specific structural and non-structural measures. Hence, SMEs will find it convenient to use this framework to design and customize measures for themselves, with some technical assistance from experts and vendors in deciding what equipment and materials to use to construct the structural measures.

The key message of this work is to encourage private-sector participation in adaptation efforts and private-sector initiatives to design, finance and implement suitable adaptation measures to build long-term flood resilience. It makes sense for the private sector to participate in this effort for the stream of benefits that would accrue from the short to long terms. This approach indeed provides a unique opportunity to find locally designed solutions for local problems, rather than relying on a top-down approach in which the government or other entities prescribe solutions that may not fit the circumstances and needs of the local users. Therefore, this approach as great potential for adoption and replication by different end-users.

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Photo credit: Teresa Anderson

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Adapting to climate change by strengthening women smallholders' access to markets

Abstract

In many countries, women make up the majority of farmers. Climate change threatens their agriculture and livelihoods, making adaptation an urgent priority. Women farmers face multiple inequalities that put them at a consistent disadvantage in growing food, accessing markets and making a living in the face of climate change. This paper outlines the need for approaches to adaptation that specifically address the multiple inequalities and obstacles faced by women smallholders in growing food and accessing markets.

ActionAid works with women smallholders and their cooperatives to strengthen their empowerment and confidence, their resilience to climate change, using agroecological techniques, and their capacity to exploit market opportunities successfully. A newly developed ActionAid methodology outlines a series of participatory tools through which women farmers can analyse their value chains and market opportunities, take action to strengthen their access to markets, and thus improve their ability to adapt to climate change impacts.

1. Introduction

Smallholder farming communities in Africa and Asia are particularly vulnerable to climate change, as their livelihoods are threatened by changing and unpredictable weather patterns. Communities must now face the increasing challenges of annual rains arriving or ending late or early, droughts, dry spells, flooding, extreme temperatures, strong winds, landslides, hailstorms, rising sea levels, and new outbreaks of pests and disease. Countries around the world must therefore strengthen their resilience to climate change. As a key component of this effort, interventions must work increasingly with women smallholders and rural communities to diversify livelihood options and improve their access to markets. In particular, working with women's collectives in this manner can be highly effective in ensuring their survival and food security in the face of challenging and unpredictable weather.

In many countries, women make up the majority of farmers and are largely responsible for ensuring food security. However, inequalities in education, attitudes, family responsibilities, access to land, credit and decision-making processes put them at a consistent disadvantage. Market places, policies and services often fail to meet and address women's specific perspectives and needs. A lack of knowledge and expertise in marketing, negotiating and analysing costs and value chains can also put women at a disadvantage in the market place. They may be using unsustainable or inefficient production processes, selling inappropriate products, or be vulnerable to exploitation and low prices.

ActionAid is an international organization currently operating in 45 countries, the majority of which are developing countries, where the organization works with poor and rural communities (ActionAid, n.d.). ActionAid's on-ground experience with projects and original research that draws from these demonstrates that approaches at the community level to identify local production potential, build relationships with various actors, create gender-sensitive value chains, build sustainable wealth and facilitate collective planning and action can strengthen women's agency for the purposes of micro-enterprise development. Such approaches can increase the resilience of women's livelihoods in the face of climate change, helping them to adapt to current and future challenges.

This paper outlines the implications of the feminization of agriculture and confronts the need for approaches that specifically address the multiple inequalities and obstacles faced by women smallholders in growing food and accessing markets, which need to be addressed if food systems are to adapt successfully to climate change. The authors show how both empowerment of women and agroecological production methods are critical components of adaptation, and present strategies that may help women farmers to overcome these challenges. The paper will then draw on examples using ActionAid's gender-sensitive methodology for working with women smallholders in vulnerable communities in order to demonstrate the enablers for improving access to markets and strengthening resilience to climate change.

2. The feminization of agriculture

In much of the developing world, women make up the majority of the agricultural labour force. In Burundi, for example, women constitute 55% of the agricultural labour force, but carry out 70% of the farm work. In Kenya, women account for 75% of the labour force in small-scale agriculture (ActionAid, 2015a). With migration trends often caused or exacerbated by climate change (ActionAid, 2016c), men are increasingly leaving rural areas for urban areas and leaving their families behind to do so. As a result, in many parts of the world agriculture is becoming increasingly feminized (International Water Management Institute, 2014). Women often grow crops to feed the family and are thus critical for ensuring food security, health and well-being not only for themselves, but also their families and wider communities.

Adaptation policies and approaches must therefore recognize that successful agriculture and food security rely on women, and must be better structured to address their circumstances and needs (ActionAid, 2011). Sadly, however, most policies are gender-blind and structured towards men's circumstances, undermining women's needs in the process (ODI, 2016).

3. Obstacles faced by women farmers in the face of climate change

Traditional patriarchal systems mean that women have major responsibilities for meeting their families' food, water and care needs (FAO, 2016). These burdens are becoming greater amid climate change, for example, if their husbands migrate to the city or abroad in the face of climate change

and crop failure (ActionAid, 2016c), or if drought leads to longer journeys to find and fetch water (ActionAid, 2016b).

Adapting to climate change can therefore provide particular challenges for women, who face additional specific obstacles and inequalities that leave them (and their dependents) especially vulnerable and that make adaptation generally more difficult than is the case for men. For example, women and girls often have less access to education and information. Cultural pressures, including prohibitions on mobility, can also inhibit women from being proactive economic agents. Moreover, women may lack access to land, as well as to credit, making it difficult for them to invest in necessary changes.

Another example is that government support, advice and extension services frequently target men farmers and cash crops, rather than women farmers and the crops that they often grow for household food security (OECD, 1997). It has been found that women farmers are frequently ignored by policy-makers and economic analyses (UN Women et al., 2015; Bertini, 2015). Women are therefore unable to build their adaptive capacities if policies and services do not reach out to them, or if analyses of the economic activity generated in a community fail to show that the benefits are not being equitably shared between men and women.

When women and the deep and underlying burdens and inequalities they face are ignored, half the world's population and the majority of the food producers, who are women, cannot flourish. Given women's disproportionate burden of care and their specific role in food provision, this also has an impact on the wider community. Effective strategies for adaptation to climate change impacts must therefore address women's specific challenges. Strategies to empower women, combined with agroecological approaches, are also key factors that can form the basis for improving women's access to markets in order to increase their earnings, livelihood options and resilience in the face of climate challenges.

4. Marketing challenges faced by women smallholders

Women smallholders must often overcome multiple challenges for their small businesses to be profitable in the local market place. In many places, the market place is considered to be the domain of men, and women's economic contributions may not be valued by their families or communities. Their economic activities may challenge preconceived notions of what they should and should not do, particularly if these are seen as conflicting with their role as caregivers. They must therefore work to overcome their own and their communities' prejudices in order to acquire the confidence to take on other challenges.

Even when women can overcome the cultural barriers to cultivating their own businesses and cooperatives, they may face further challenges in the market place. Buyers do not always treat producers fairly, and women are often particularly vulnerable to unequal power dynamics. For example, when trying to sell their produce, their low degree of bargaining power may mean that they struggle to dictate prices, and as a result they often end up on the losing end of the deal (FAO, 2011). Furthermore, women are often left out of local committees or relevant decision-making bodies and processes (Womankind, n.d.). As a result, local policies and rules on how markets should operate often fail to reflect women's perspectives and needs.

In addition to these external challenges, a lack of knowledge and experience, particularly in marketing, can put women and their small businesses at a disadvantage. There are multiple areas along the value chain in which they may be losing out, for example, in understanding how to optimize their production processes sustainably, or in ensuring a good balance between costs and returns. Inexperienced women's cooperatives may not have a good understanding of how markets really operate, what buyers are looking for, how gender affects dynamics in the market place, or how win-win relationships can be established with buyers.

5. What key processes can support women-owned agricultural small businesses to adapt to climate change?

ActionAid has learned key lessons over several decades of working with women farmers and their small and micro-enterprises in developing countries. In recent years, this work has focused primarily on building communities' and women's adaptive capacity in the face of climate change.

First, ActionAid's experiences on the ground have shown that *women's empowerment* is an initial essential step to rooting strategies in communities and ensuring greater impact. Secondly, for agriculture-specific programming, *training in agroecology* has proved to be an effective strategy for strengthening resilience and delivering multiple benefits to women, their communities and their environment. Lastly,

generating opportunities to strengthen women's access to markets by diversifying their livelihoods is found to be key to increasing their earnings, livelihood options and resilience in the face of climate challenges.

5.1 Women's empowerment

Tackling poverty and the challenges of climate change and adaptation requires a focus on helping women to exercise their right to participate, become leaders and make decisions. Adaptation approaches at the community level should therefore ensure that women are prioritized and given additional support for their participation in activities and offered training for empowerment. The creation of women's groups, where women can speak openly, learn freely and offer mutual respect and support, can enable women to grow in confidence. In working towards women's empowerment, some organizations, including ActionAid, provide additional support to improve key skills such as literacy and numeracy, thus giving women the chance to make up for missed educational opportunities and strengthening their confidence to engage in analysis, record-keeping and communication. Using these skills, women's groups can then undertake collective analysis, planning and action. They can also engage together in developing and implementing community adaptation plans and can form cooperatives to produce and market their produce and products.

Facilitating women to learn about their rights and to understand the responsibilities of "duty-bearers" such as governments can yield profound results. Women can learn that they may approach local government to alert them of issues and to ask for change, improvements or the provision of services and support. This can produce great results. ActionAid has found that local governments frequently respect and respond to input and information from citizens and welcome hearing specific recommendations on how local budgets can be spent (ActionAid, 2017a). The combined effect of these processes on women's empowerment, confidence and ability to take action can be significant, as expressed by Coumba Ciss, who is vice president of a local women's group in Bady village in Senegal's Kedougou region:

"Before the project I was so shy. But now we are confident and we have learned about our rights. Through our discussions we realized we could make key changes to how we do things. I even went to ask the local mayor for support to buy a milling machine for the village. This project has taught us that we can cope with the changing climate, and that by organizing together as women we can improve our lives." (Participant, interview with author Teresa Anderson, December, 2016)

To this, Talan Sagna, chief of the village, added æhis thoughts: *"When the women benefit, the whole family benefits too, including the men. Whenever there is a group discussion, it improves life in the village."* (Indirect beneficiary interview with author Teresa Anderson, December, 2016).

The confidence, as well as the literacy, numeracy and analytical and communication skills that are developed through these empowerment processes, are key to enabling women to engage effectively as small businesses in the market place. Skills and confidence enable women to approach buyers, negotiate deals and keep records that enable them to analyse the cost-effectiveness of their decisions. Above all, empowerment is the essential first step that allows a woman farmer to imagine her potential and pursue her goals.

5.2 Training in agroecological techniques

Farmers around the world must learn to adapt their agricultural systems to changing weather patterns, and agroecological techniques, which apply ecological principles to agriculture, can be a key strategy for achieving this. Instead of using agrochemicals such as synthetic fertilisers, herbicides and pesticides, farmers can use natural approaches. These include: adding organic materials such as compost, manure or mulches to soils; using natural pest control techniques; and enhancing local crop diversity.

These techniques are proving particularly effective in the face of erratic rainfall and extreme weather patterns. The addition of organic materials improves soil structure, helping it to absorb more water and to retain it in times of low rainfall and drought, as well as to retain its structure during heavy rainfall and flooding. By increasing locally-adapted crop diversity, farmers can also spread their risk and reduce the likelihood of crop failure. Climate change will also increase pest attacks; integrated pest control and formulations made of natural ingredients can help farmers to avoid dependence on dangerous and expensive chemical pesticides. With unpredictable and extreme weather events on the increase as a result of climate change, these agroecological production methods must increasingly become the norm to help farmers cope with multiple challenges (ActionAid, 2017b). More than just a means of production, agroecology also allows farmers to become less

dependent on expensive agribusiness inputs, so that they can retain more of their income, power and knowledge.

These techniques are often well suited to the realities and challenges faced by women farmers, as explained by Penda Mballow, a farmer in the Gambia:

"Farming has become more and more difficult in recent years. Now the rains come at strange times, and for unpredictable duration. But the compost we are using now makes the soil soft and dark, and it holds the water much better. This year we had a very short rainy season, as the rains arrived nearly two months late. But because the soil is now full of organic matter from the compost, it could hold enough water to help the crops reach maturity." (Participant, interview with author Teresa Anderson, October, 2014)

Lucy Sinkhani, a farmer in Neno District, Malawi, was on the frontline of the drought caused by El Nino in 2015-16. The rains that fell that year were brief, and across the country there was widespread crop failure and hunger, but for Lucy the impacts were different:

"We were shown how to apply grasses as mulch on our garden. When it rained, the soil kept the moisture. It was like a blanket making sure the moisture did not evaporate. Because of this practice, I will harvest a normal yield, whereas many people will only harvest a third of their normal harvest. I got staggering results considering this was a year with very poor rainfall." (Participant, interview with ActionAid Malawi, May, 2016)

As shown by these examples, agroecological practices provide several advantages for women seeking to strengthen their small businesses and access to markets. The reduced requirement for costly inputs such as chemical fertilizers and pesticides can also free up more income for take-home profit or further investments. Improving the resilience of their crops to climate impacts increases the likelihood of decent yields and incomes, thus ensuring a reliable supply to their buyers. These techniques also produce higher quality organic products that can generate higher returns in the market place.

However, in many countries women do not have secure access to land. This inequality not only serves as a barrier to women's engagement in agriculture and markets, it can also dis-incentivize them from investing the time and effort to shift to agroecological techniques. Unfortunately, in most countries government services, such as extension services, public research institutes and universities, as well as corporations, continue to promote a model of agriculture that is reliant on agro-chemicals and hybrid seeds, which frequently serve to undermine the agroecological model of agriculture upon which this approach is based.

5.3 Generating opportunities for strengthening women's access to markets

Increasing opportunities to access markets and improving the profitability of products are key to helping women farmers adapt to climate change. Strategies can include improving production processes to be more sustainable, efficient and cost-effective, and understanding the market place in order to develop products that can meet demand and increase the leverage for profit. In reducing costs and increasing earnings, women smallholders can make better use of their available natural resources, as well as of their time and efforts. They can thus generate better incomes, and thereby strengthen their families' resilience to climate change.

Supporting women to form groups and work together can be a key strategy for strengthening women's access to markets. ActionAid has found this approach to be particularly effective when combined with strategies that strengthen women's empowerment, as outlined earlier. Bringing women together in this way can allow them to identify and make the best use of their collective skills, knowledge and bargaining power. Together, they can then analyse their production processes, costs and incomes, how their gender affects power dynamics, their control over resources, environmental sustainability and long-term trends such as climate change. Women's groups may thereby challenge their preconceptions about markets and increase their collective knowledge. They can explore existing and new produce, as well as alternatives for processing and packaging, in order to increase their market access.

New marketing opportunities can be identified in a diverse range of formal and informal market places, from the local and village level up to district, regional, urban and national markets. Institutional markets can also offer new opportunities, for example, in selling collectively to governments, institutional procurement programmes and cafeterias for departments, schools, universities and hospitals. Some farmers are also beginning to explore the

potential of social media as a marketing platform. Local, informal and territorial markets are likely to provide particular opportunities for women smallholders to bargain and develop win-win relationships. By engaging with local economies, smallholders can also contribute to the circulation of wealth in the region (CSM, 2016).

New marketing opportunities can also be developed through buyers and producers working together. For example, agroecological products, such as organic fruit, vegetables or preserved products, that are healthy, nutritional and advance women's rights can create new markets that benefit producers, buyers and end consumers. Such win-win relationships require a mutual understanding of what it takes for both buyers and producers to succeed over the long term and how they can contribute to each other's success. Buyers also need to understand issues concerning climate change and its likely impact on food production. By developing good relations with buyers, women cooperatives can help the latter to understand these trends, and can influence them to adapt their business strategies accordingly. They may find that, by working together, producers and buyers can shape the market and consumer demand to cope with the challenges ahead, for example, by cooperating to increase consumer interest in products that are likely to survive in the face of reduced rainfall, such as millet.

Local women's groups can therefore follow processes that facilitate a gender-sensitive approach to strengthening their access to markets and value chains, by improving their understanding of their own weaknesses, challenges, potential and market opportunities. In this way they become more self-sufficient and independent, able to take control of their access to market initiatives and capable of identifying their own needs. Thus they can create new possibilities for income generation that give them more resilient livelihoods, helping them to adapt to climate change (ActionAid, 2015b). When women's groups feel ready to grow their businesses further, governments can play an additional important role, for example, by providing advice on health and safety requirements, or information on available technologies for processing.

Diversification of crops and livelihood options can also make a significant difference in helping women farmers to adapt their agriculture to climate change, to access or create new markets, and thus improve their earnings. Many communities are traditionally dependent on agriculture for the entirety of their income and food security. However, in the face of extreme weather events, crop failure may mean that the family will starve. They may be particularly vulnerable if they are growing just one crop that has become vulnerable to climate change, leaving them highly exposed to climatic risks. Efforts to support the diversification of both crops and livelihoods can thus help make women more resilient in the face of disasters. Narmaiya Bisenke, a woman smallholder from Marse Village, eastern Nepal explains:

"Last year there was no rain for eight months in a row, which we have never seen before. Normally we would be harvesting our maize by now, but you can see that because of the lack of rainfall the crop is still growing and the harvest is delayed… Before the project we didn't know that multi-cropping was an option. Now we are growing tomatoes, cauliflower, beans, chillies and many other organic vegetables."

Narmaiya and the other women farmers in the village are selling these organic vegetables to a local hotel at a much better price than they earn from selling maize on the open market: *"We get a much better income from growing vegetables and fruit, and it is better for our diet too, as we are eating many more vegetables"* (Participant, interview with author Teresa Anderson, July, 2016).

Women may also find opportunities to process new products that they can sell for a better profit, such as pickles, powdered infant feed from bananas or concentrated juice cordials. They may also decide to develop non-agricultural products such as honey, batiks, baskets, scarves or pottery. Processed and non-agricultural products can be stored for longer and can be sold year-round, which means they can be a useful means of earning income during the lean season, when times are usually at their hardest.

6. Approaches and methodologies applied by ActionAid

ActionAid's approaches to women's resilience to climate change, empowerment (ActionAid, 2013), agroecology (ActionAid, 2016a) and access to markets (ActionAid, 2018) are built upon many years of experience in using a participatory human rights-based approach. They are especially designed to facilitate the participation and engagement of marginalized communities and individuals, recognizing the intersection of gender with other factors such as age, race, caste, sexual orientation and disability. The approach is highly attuned to the cultural challenges that

many women face in participating as thinkers, leaders and economic actors in their communities. Project facilitators are encouraged to take account of power differentials in communities and to use strategies that avoid perpetuating them.

While approaches to improving small and medium enterprises' access to markets often focus on income generation, including recruiting external consultants to assess marketing opportunities, ActionAid's approach is substantially different. Instead, community women's groups undertake the analysis of marketing opportunities themselves through discussions using participatory tools. This approach makes fuller use of women's inherent agency, potential and knowledge, enabling them to analyse value chains independently, draw out gender perspectives and examine the economic, social and environmental sustainability of marketing initiatives. Ultimately, this approach seeks to ensure that all actors in the value chain benefit, thus creating wealth for all. Accessing markets should therefore not be seen as a process of subjugating the interests of local producers to external market forces. Instead, it takes the view that markets must respect the environment (including environmental realities such as climate change), promote gender equality and women's rights and ensure food security. The approach empowers local producers to respond to and shape market demand, for example, by working with other actors to create a market for products that are adapted to climate change or other realities.

The approach followed by ActionAid is based on participatory methodologies that draw out women's knowledge, insights and confidence, through which they undertake research, reflect on their findings and initiate conversations with potential buyers. Seven different components help groups to build a full picture of their production systems, their potential in the market and the steps that need to be taken. These components cover the questions of: 1) identification of local production potential; 2) collectives' reflections on the market; 3) building relationships with markets; 4) gender-sensitive value chains to support collective goals; 5) gaps and risks in the value chain; 6) building sustainable wealth that sticks; and 7) developing a collective plan of action. Different specific participatory processes or "tools" can be used to help build a picture of each component, but these can be addressed in different orders and adapted to local contexts. There is no need to use the full range of tools for each component, as the methodology includes nearly thirty tools or processes in total. The methodology has evolved through ActionAid's experience of programmes on the ground, and it has recently been consolidated into a formal framework that will be published shortly (ActionAid, 2018). However, it is still a living methodology that will continue to improve and develop.

Women farmers in Bangladesh use the "Timeline" process to better understand changes and trends that have influenced their production and marketing over decades. Photographer: Celso Marcatto

Group of seed producers in Burundi use the "leaky bucket" process to calculate their profits. Photographer: Celso Marcatto

Project facilitators in ActionAid programmes therefore use these participatory tools to facilitate vibrant discussions, games, role plays, research exercises and planning processes to lead to strategic changes. It is important to note that low literacy levels among women smallholders can exclude them from full participation in these participatory processes unless careful steps are taken. Alternative approaches can help to balance participation in the group. For example, when developing a "map" of the local area, its resources and key points of activities, the group can substitute a drawing with sticks, pebbles, leaves and local materials to draw a picture of the area. Often people feel more confident in engaging in a process in this way, as they may feel reluctant to use a pen, or to cross out others' pen marks to make a change.

Tools for initially identifying local production potential include developing timelines to understand how and why changes in practices have been experienced over the years; mapping assets to identify resources, skills, storage, processing and transport facilities; and drawing up seasonal calendars to understand the timings of activities, as well as lean seasons and coping mechanisms, which are particularly important in the face of climate change.

A tool called "leaky bucket", in which participants draw a picture of a bucket together using arrows in and out to represent incomes and expenses, can help farmers to come to useful new conclusions. Power and gender analyses can also motivate women to address inequalities. For example, in Ethiopia the "leaky bucket" process helped farmers identify the high costs they were paying for irrigation. Together they collected and raised enough investment to purchase PVC pipes to connect them to the local canal and saved much more in the long term by managing their own water supply for irrigation.

After understanding their own production potential, the groups are then facilitated to reflect collectively on the market. Tools used here include collectively drawing up flow charts to identify channels and actors, ranking different actors, walking through the market place to identify products, actors and potential new opportunities, and group discussions. The work then begins for the cooperatives to build their relationships with markets, to obtain a clearer understanding of what motivates buyers and end-consumers, and to understand how new technologies, trends and better access to information can create opportunities. The tools used for this component include games, role-play conversations and interviews.

The women's cooperatives can then begin to develop a clear sense of how their gender-sensitive value chain supports the collective's goals. Tools include visually mapping the value chain system and analysing these maps through a gender lens to show the specific challenges and opportunities that women face, such as access to key resources including land, tools, credit, education, extension services and transport options, as well as the specific roles that they might be expected to take in the value chain. Participants then identify the risks and rewards of challenging gender roles so as to minimize risks and strengthen their ability to engage effectively. In Uganda, as a result of such a power and gender analysis, women farmers identified the fact that women did

not have the right to own land as one of the key barriers preventing their effective participation in markets. They decided to form a producer group using donated land, and this led to their successfully exercising control over their production and sales, and even using their lobbying power as a group to influence local government policies.

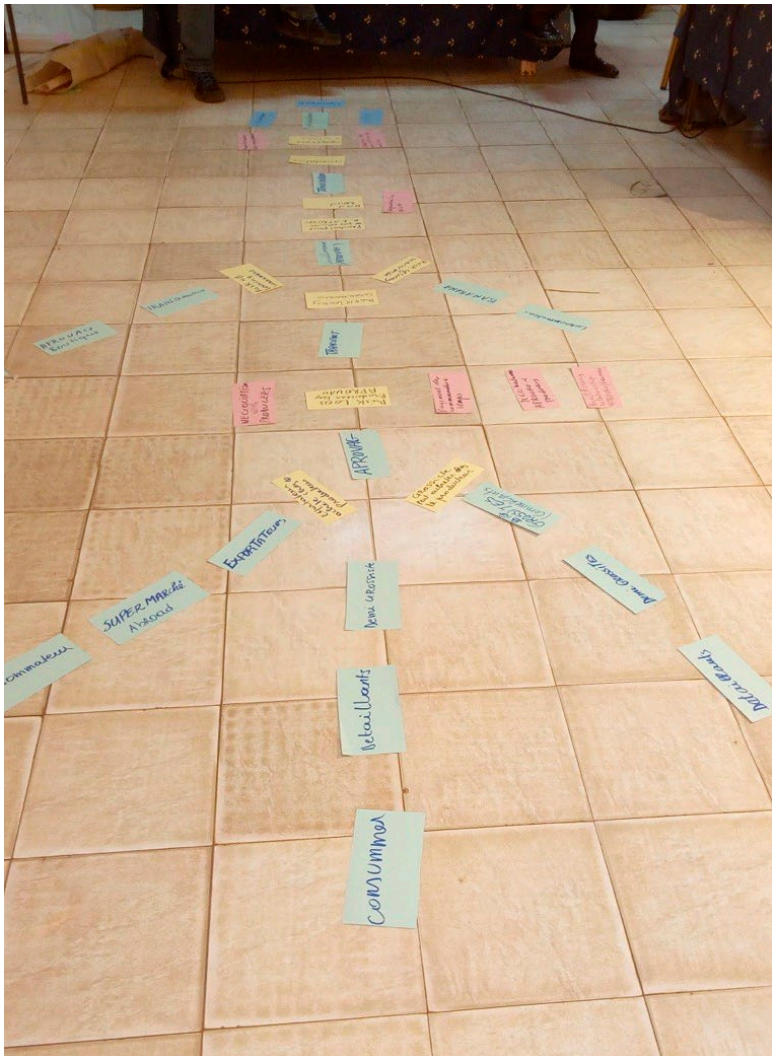
The next steps then help the group to identify gaps and risk in the value chain, build sustainable wealth and develop a collective plan of action. Methodologies to empower women take account of the gender-based inequalities and challenges they face and recognise that their agency and potential as small and medium enterprises can be highly effective in strengthening adaptation to climate impacts.

It should be noted that, while ActionAid's approach to strengthening women's access to markets has been applied, tested and developed in an iterative process in countries across the organization's international federation, this approach has only recently been formalized into a framework. Although the process has been devised on the basis of real-world programming, the scaled-up application across countries provides new opportunities for testing and learning, including from the problems and challenges that a new methodology is likely to face in new contexts.

A foreseeable limitation of this participatory approach to strengthening women smallholders' access to markets is that it will be less effective if it is not introduced in conjunction with parallel approaches to women's empowerment and agroecological techniques, as outlined in the earlier part of this paper. For development organizations, ensuring a deep and rooted understanding of these concepts across all countries, projects and communities requires constant investment, capacity-building and follow-up to ensure programme quality, which is time-consuming. In spite of these limitations, ActionAid has nonetheless found this approach to be the most effective and sustainable in generating new opportunities for building the capacity of women smallholders to adapt to climate change.

7. Conclusion

For vulnerable food systems to be able to adapt successfully to climate change, agriculture policies and programmes must recognize the huge potential and agency of women farmers and their small and medium enterprises, the role that strengthening their access to markets can play, and the specific gender-based inequalities and barriers they face.



Mapping the value chain for banana production, Senegal.
Photographer: Serigne Ndiaye

Civil-society organizations and government initiatives must actively strengthen women farmers' access to markets as part of their formal climate adaptation initiatives.

Strategies that empower groups of women smallholders to work together to analyse and understand their local markets, establish win-win relationships with buyers and produce, process and market their items sustainably and profitably can be highly effective. Focusing on women's empowerment brings with it multiple benefits (IDS, 2006), such as addressing the underlying inequalities of market access, status, skills and knowledge, while also bringing broader benefits to women's families and communities. By working collectively, women can increase their ability to

organize and negotiate, as well as benefit from each other's intellectual capital (ActionAid, 2015b).

Agroecological techniques are found to be key to successful adaptation by smallholders (Altieri, Nicholls, Henao, & Lana, 2016). These approaches, which use ecological principles and locally available resources, are also better suited to women farmers' economic and social realities than agricultural techniques that require expensive chemical inputs (ActionAid, 2014). Also, agroecology meets women's families' nutritional needs better. However, women often struggle to access markets effectively with their products, and they often find themselves on the losing end of deals when negotiating with buyers (ActionAid, 2015b).

Developing new products, both agricultural and non-agricultural, may help women diversify their income options, thus providing families with income and food security during the off-season or in cases of crop failure. Alternative livelihood options can give families an important sense of security (Makate, Wang, makate, & Mango, 2016; Wan, Li, Wang, Liu, & Chen, 2016), allowing them to remain in farming, instead of migrating to urban areas in the face of climate change challenges (Ward & Ruckstuhl, 2017).

Methods and approaches that support women's empowerment, agroecological production methods and the diversification of livelihoods can provide the basis for successful agricultural adaptation. For women and their families to be able to guarantee their survival in the face of the multiple challenges of climate change, participatory and gender-sensitive approaches to strengthen women's access to markets will be key.

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