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ABSTRACT

Climate change impacts threaten existing development efforts and achieving future sustainability goals. To build resilience and societal preparedness towards climate change, integration of adaptation into development is being increasingly emphasized. To date, much of the adaptation literature has been theoretical, reflecting the absence of empirical data from activities on the ground. However, the Funds established under the United Nations Framework Convention on Climate Change and managed by the Global Environment Facility, the Least Developed Countries Fund, the Special Climate Change Fund and the Strategic Priority for Adaptation, have approved financing for 133 adaptation projects in 70 countries with sufficient documented experience to allow for initial categorization and evaluation. This article provides the first substantial compendium of adaptation actions identified through the allocation and disbursement of these Funds and organizes these actions into a generalized typology of adaptation activities. The information obtained sheds new insight into what adaptation is, in practice, and suggests some next steps to strengthen the empirical database. Ten types of overarching adaptation activities were identified through an analysis of 92 projects financed through these Funds. This paper analyzes these adaptation activities and compares them with theoretical constructs of adaptation typologies. We find that many of the early ideas and concepts advanced by theoreticians are consistent with results from the field. The adaptation categories that recur the most in Global Environment Facility projects are enabling and relatively inexpensive measures, such as those related to capacity building, policy reform, and planning and management. However, a rich panoply of technical actions ranging from information and communications technology, to early warning systems, to new or improved infrastructure, are also identified as common project goals. Future refinements of the costs of various adaptation actions, the mixture of technical and management options, and evaluating the efficacy of actions implemented, will be key to informing the future global adaptation agenda.

1. Introduction

Social, economic, and ecological adaptations to change are not new. Human beings have been adapting to climate variability and change throughout the centuries. Today, however, significant amounts of manmade greenhouse gas emissions have altered Earth's climate, raising temperatures 0.8 °C above pre-industrial levels, increasing the frequency and intensity of droughts and floods, and raising sea levels (IPCC, 2012; SREX, 2010). Additionally, the rapid growth in human population and economies globally, significantly concentrated in areas exposed to climatic harm, means that the risks of losses from climate change will continue to increase.

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The confluence of these factors are necessitating action to proactively adapt natural, built, social, and economic systems. Unfortunately, given the pace and magnitude of changes underway, the measures developed in the past to cope with climate variability may, in many cases, no longer be sufficient to adapt to the unprecedented impacts of climate change (Bierbaum et al., 2013; Kates et al., 2012).

Climate change is already affecting various areas around the world: many recent extreme weather events such as floods in Australia and Colombia, droughts in the United States and East Africa, and wildfires in Russia are the types of events expected due to climate change (Babatunde et al., 2013; Peterson et al., 2012). Evidence has shown that the impacts of a changing climate are of greatest concern in the most vulnerable and poorest countries and communities within the developing world (Tschakert, 2007). These countries and communities are vulnerable to climate change, including extreme weather events, because of their disproportionate exposure to climate impacts as well as a lack of adaptive capacity – the resources, institutions, and technical capacity needed to recover when such events occur (Djoudi and Houria, 2013; Reid et al., 2010). For example, the Intergovernmental Panel on Climate Change Working Group II (IPCC, 2007), the World Development Report 2010 (World Bank, 2010), and a recent African Academy statement (African Academy, 2012), among others confirm that Africa is one of the most vulnerable continents to climate variability and change because it faces multiple stresses, now increasingly confounded by more droughts and more floods, and has low capacity to adapt to these changes (The World Bank, 2012; World Bank, 2013a,b).

At the most general level, climate adaptation or coping, is what people do to avoid and recover from unusual or extreme climate events. In recent years, as interest in proactively funding and implementing adaptation programs and projects has increased, the need for a more precise definition of climate adaptation has become apparent. A 2006 Organization for Economic Cooperation and Development report reviewed the range of definitions for "adaptation" noting important differences in definitions prepared by the Intergovernmental Panel on Climate Change, United Nations Framework Convention on Climate Change, United Nations Development Program, and United Kingdom Climate Impact Program, with potentially significant operational and funding implications (OECD, 2006) (see Table 1):

> "All four definitions differ from one another in several ways. First, they all use different words to describe what adaptation is. The first key words in the definition that express adaptation as 'adjustment', 'practical steps', 'process' and 'outcome' can be interpreted differently by various stakeholders. . .Expectations from adaptation as an outcome might be much higher than expectations from it as a process. Funding aspirations and evaluation of achieved results would also vary accordingly." (OECD, 2006)

As the impacts of climate change become increasingly recognized in various social, economic, and policy spheres, efforts to understand and define adaptation will likely intensify, thus giving urgency to efforts of translating the existing evidence on adaptation into a practical ontological system. Without efforts to marry adaptation theory with real-world adaptation practice, the adaptation field will continue to be siloed between theory and practice. It is important to begin to develop 'lessons learned' and 'best practices' from the practitioner world. This article shares ten years of operational experience built through the implementation of adaptation projects around the world, in an effort to unite empirical data with the ongoing academic discussion on climate adaptation activities. This is done by comparing adaptation efforts financed through the Global Environment Facility with existing typologies of adaptation activities present in the peer-reviewed literature, and identifying similarities, discrepancies, and areas for further study with an ultimate aim of advancing both theory and practice.

2. Existing adaptation typologies in the literature

Various typologies of adaptation activities have been created over the last two decades, with finer specification and detail emerging recently. A literature review by Smit et al. (2000), supported by subsequent work found that existing typologies of adaptation activities generally focus on one of five main areas: timing relative to stimulus (anticipatory, concurrent, reactive), intent (autonomous, planned), spatial scope (local, regional, national), form (e.g., technological, behavioral, financial, institutional), and degree of necessary change (incremental, transformational) (Carter et al., 1994; Fidelman et al., 2013; Huq et al., 2003; Smit and Skinner, 2002; Smit and Wandel, 2006; Wilbanks and Kates, 1999). In addition to the categories identified by Smit et al. (2000), other typologies have focused on the driver of action, with the primary drivers being disasters, climate variability, and climate change (Smit et al., 2000; Cutter et al., 2008). Given that projects within the Global Environment Facility portfolio are planned and generally anticipatory, our analysis, and the remainder of this section, focuses on the various forms of adaptation being implemented irrespective of spatial scope and intention.

Work conducted by Eakin et al. (2009) identified three distinct forms of adaptations: (1) social vulnerability approaches aimed at addressing underlying social issues; (2) resilience approaches focusing on enhancing a systems resilience; and (3) targeted adaptation approaches which target actions to specific climate change risks. This high-level "type" of adaptation classification can be refined by adding a more detailed typology of adaptation actions such as that presented by Burton et al. (1993) which includes: prevent loss, tolerate loss, spread loss, change use or activity, change location, or restoration. This is similar to work by Bijlsma et al. (1996), which uses the categories of retreat, accommodate, or protect to classify adaptation actions.

Similarly, Berrang-Ford et al. (2011) developed a methodology to track and categorize adaptation forms and tested it against adaptation actions found in peer-reviewed, English language

Table 1
Common definitions of adaptation.

Intergovernmental Panel on Climate Change	Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation (IPCC, 2007)
United Nations Framework Convention on Climate Change	Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (UNFCCC website)
United Nations Development Program	Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, or implemented (UNDP, 2005)
United Kingdom Climate Impacts Program	Adaptation is the process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits, associated with climate variability and climate change (UKCIP, 2003)

literature. The primary divide used by the authors was the 'intention' to act versus real action. For those strategies deemed adaptation actions, the authors found that actions in low-income countries tended to be reactive and focused on avoiding, retreating, coping, accommodating, adjusting, spreading risk, or securing income or resources. In high-income countries, the author's found that adaptations tended to be proactive and focused on planning, monitoring, increasing awareness, building partnerships, and enhancing learning or research (Berrang-Ford et al., 2011). Similar to the types of adaptation activity found by Berrang-Ford et al. (2011), the UK Climate Impacts Programme uses four categories to classify adaptation forms: living with risks and bearing the losses; preventing effects by reducing exposure; sharing responsibility through efforts like insurance programs; or exploiting opportunities (UKCIP, 2005, from Biesbroek et al., 2010).

Lesnikowski et al. (2011) and Lesnikowski et al. (2013) used an approach similar to Berrang-Ford et al. (2011) to categorize adaptation activities, arriving at three forms: recognition, groundwork, or adaptation action. In this classification, recognition activities demonstrate awareness but do not indicate any action has been taken. Groundwork actions are preliminary steps that inform and prepare stakeholders for action but do not constitute actual changes in policy, programs, or delivery services (Lesnikowski et al., 2013). Groundwork actions include things such as vulnerability assessments, adaptation research, development of conceptual tools, stakeholder networking, and provision of policy recommendations. The final category, adaptation actions, refer to tangible actions taken to "alter institutions, policies, programs, built environments, or mandates in response to experienced or predicted risks of climate change. The eight types of adaptation actions include: legislative change, department development (working groups, ministries, departments), public awareness and outreach, surveillance and monitoring, infrastructure and technology, program or policy evaluations, financial support for autonomous adaptation, and medical interventions" (Lesnikowski et al., 2011: 1155).

Dupuis and Biesbroek (2013), drawing upon work by Fussel et al. (2012), looks specifically at adaptation policy and creates a distinction between "measures that enable the conditions necessary for an adaptive response (e.g., capacity building, reducing the social drivers of vulnerability), and the policy activities which specifically target the effects of climate stimuli and the resulting vulnerability..." (p. 5). Using this dichotomy, they create a four-part theoretical typology of adaptation policy: symbolic policy, contiguous policy, contributive policy, and concrete policy (Dupuis and Biesbroek, 2013). Similar work by Castán Broto and Bulkeley (2013) looked at different types of adaptation-related governance, identifying four modes: self-governing, provision, regulations, and enabling.

These higher-level, often theoretical classifications of adaptation forms have only recently been tested by looking at empirical examples at the local, national, and regional levels. For example, in their analysis of adaptation activity in the United Kingdom, Tompkins et al. (2010) used building adaptive capacity, implementing adaptation, and developing a supportive legal and institutional environment as a typology to classify adaptation actions. These three categories were used to classify over 300 discrete adaptations, which were grouped into eight main types of activities: research, plan, networks, legislation, awareness raising, implemented change, training, and advocacy. Interestingly, of these eight categories, six related to building adaptive capacity (research, planning, networking, awareness raising, training and advocacy). Similar work conducted by Fidelman et al. (2013) looking at adaptations in the Great Barrier reef found six discrete forms of activities: information and research; policy, plans, programs; legislation; organizational structures; tools and guidelines; and committees and networks.

Eisenack et al. (2012) simplify form-based adaptation types by focusing on three types of adaptation "means" in the transportation sector: institutional, technical, and knowledge. Similarly Smit and Skinner (2002) developed a typology of adaptation to classify and characterize agricultural adaptation options in Canada. Their four types, which are not mutually exclusive, include: technological development; government programs and insurance; farm production practices; and farm financial management. Actions such as the provision of information are considered by Smit and Skinner (2002) to be stimulators of adaptation initiatives but not direct adaptation actions. A similar analysis by Ayers and Huq (2009) identified institutional policies, public/private arrangements in things such as technologies and building infrastructure, and livelihood-based approaches as primary adaptation techniques available to the agricultural sector. In a study of Inuit adaptation, Ford et al. (2010) found six types of adaptation-related opportunities to "establish or strengthen conditions favorable for effective adaptation in the Canadian Inuit population: harvest support; co-management of wildlife resources; land skills training; capacity assessment in search and rescue; food systems enhancement; infrastructure protection" (p. 183). Similar work by Tompkins (2005) identified three categories of activities in the Cayman Islands that could be promoted to increase the resilience of social institutions: attitudinal change, behavioral change, and institutional change.

Work within the hazards community has also helped to advance specific classifications of adaptation types based on form (Cutter et al., 2008; Travis, 2010). Six classifications used in the hazards community that denote key human response pathways for addressing hazards include: technological control and intervention of the physical phenomena; physical protection and barriers to make places safe from the hazard; monitoring, forecasting, and warning systems; building codes and engineering design standards to reduce damages from events; relief and insurance mechanisms to spread the burden and support recovery and reconstruction; and land use changes to reduce underlying exposure and vulnerability (Travis, 2010).

While existing categorizations of adaptation actions have helped to understand the possible form of adaptation, more information is needed to ground-truth these theoretical classifications with on-the-ground adaptation activities (Eisenack and Stecker, 2012; Tompkins et al., 2010).

3. Financing for adaptation activities in developing countries

While the Intergovernmental Panel on Climate Change, the World Bank, the Joint Science Academies, and others, with increasing urgency, have stated that there is a strong need for both climate mitigation and adaptation actions (IPCC, 2007; World Bank, 2010; Joint Academies, 2008, 2005), mitigation actions have historically consumed a greater focus during the United Nations Framework Convention on Climate Change negotiations (Huq, 2005; Schipper, 2006, 2007). The guidance on adaptation activities to countries and to the Global Environment Facility, the operating entity of the Financial Mechanism of the Convention, was initially limited to financing vulnerability and adaptation assessments and studies, with some focus on capacity building, but extremely limited focus on implementation of adaptation actions (Huq, 2005).

Despite the need to address adaptation as well as mitigation, the first formal donor commitment to adaptation financing under the United Nations Framework Convention on Climate Change was at the 7th Conference of the Parties in 2001 in Marrakech (Marrakech Accords) (O'Sullivan et al., 2011). The Marrakech Accords established four new avenues to finance adaptation actions and moved the funding priorities from studies and assessments to concrete activities to reduce vulnerability and increase adaptive capacity of vulnerable communities, sectors, and

countries. To support adaptation, the following funds were created: the Least Developed Countries Fund, the Special Climate Change Fund, an adaptation pilot in the Global Environment Facility Trust Fund named the Strategic Priority for Adaptation, and the Adaptation Fund that was financed through a share of proceeds of the Certified Emissions Reductions from the Clean Development Mechanism of the Kyoto Protocol (Table 2).

The Conference of the Parties requested that the Global Environment Facility establish an adaptation pilot in its conventional Trust Fund and manage the Least Developed Counties Fund and the Special Climate Change Fund by mobilizing additional resources, defining eligibility criteria, and distributing funds for eligible activities. Six years later, at the Conference of the Parties-13 in Bali, the Meeting of the Parties to the Kyoto Protocol, asked the Global Environment Facility to provide secretariat services to the Adaptation Fund (but since the Global Environment Facility does not manage the Adaptation Fund, we do not consider its projects in this analysis). The Adaptation Fund, Least Developed Counties Fund, and Special Climate Change Fund are all governed by and report to external bodies.

The process of initiating adaptation financing posed innumerable challenges beginning with the need to define criteria and procedures for eligibility. Commonly used definitions of adaptation, including those in the literature or Convention decisions, were not sufficiently specific for operational clarity and consistency (OECD, 2006). Moreover, a lack of agreement amongst the negotiating countries, project proponents and agencies on what specifically had to be financed and a lack of consistency regarding how much funding was required created additional hurdles for the Global Environment Facility and its network of partners (Klein et al., 2005; Schipper, 2006; O'Sullivan et al., 2011). Further, in practice, the scalar shift from high-level policy and broad goals (e.g., "reducing vulnerability") to precise expected project outcomes and outputs came with the operational challenges of designing and implementing projects and programs, without a common understanding and definition of adaptation in practice.

With 48 countries eligible for Least Developed Countries Fund support and more than 100 developing countries potentially eligible for support from the Special Climate Change Fund, it was essential to create a system that was functional and accessible by the recipient countries without compromising standards for effective oversight and financial accountability. In responding to these challenges, the Global Environment Facility and its network of partners developed a new financing framework that included a number of changes, including the integration of "climate-resilient development," or development that meets current and future needs despite a changing climate, into conceptualization of adaptation as well as the concept of "additional costs" which meant that Global Environment Facility funds would be used to pay only for the additional portion of a project required to ensure preparedness for climate change (O'Sullivan et al., 2011).

As a result of these efforts, the Global Environment Facility has supported a broad portfolio of on-the-ground adaptation projects financed under the Least Developed Countries Fund, the Special Climate Change Fund, and the Strategic Priority for Adaptation. To-date, however, no systematic concerted efforts have taken place to analyze the types of adaptation projects financed through these Funds. There have been, however, somewhat similar analyses

Table 2
Summary of UNFCCC climate-related funding mechanisms.

UNFCCC Climate-Related Funding Mechanism[a]	Brief Description of Instruments Related to Adaptation	Convention Guidance for Integrating Adaptation into Climate Change and Sustainable Development
Global Environment Facility Trust Fund	Contributions from donor states based on replenishment[b] and establishes guidelines for project funding through Council Meetings based on the general criteria of providing "global environmental benefits." The Global Environment Facility Trust Fund includes the Strategic Priority for Adaptation (SPA)[c], a Pilot program, operational in July 2004, of US $50 million	Establishes pilot and demonstration projects to show how adaptation planning and assessment can be built into projects that provide real benefits and be integrated into national policy and sustainable development planning (UNFCCC Decision 6/CP.7)
Least Developed Countries Fund	Voluntary contributions by donor nations for adaptation in least developed countries. Policies and procedures established by the Least Developed Country Fund/Special Climate Change Fund Council. The Least Developed County Fund supports a work program to assist least-developed countries with carrying out, inter alia, the preparation and implementation of National Adaptation Programs of Action	Promotes the integration of adaptation measures in national development and poverty reduction strategies, plans or policies (UNFCCC Decision 3/CP.11)
Special Climate Change Fund	Two active financing windows to which nations voluntarily contribute, for the benefit of developing countries. The Special Climate Change Fund finances projects relating to four areas: (a) adaptation; (b) technology transfer and capacity building; (c) energy, transport, industry, agriculture, forestry, and waste management; and (d) economic diversification. Policies and procedures established by the Least Developed Country Fund/Special Climate Change Fund Council	Contributes to the integration of climate change considerations into development activities (UNFCCC Decision 5/CP.9)
Adaptation Fund	Two percent of Clean Development Mechanisms projects funding supports the Adaptation Fund. Policies and procedures for funding established by the Adaptation Fund board	

[a] According to the United Nations Framework Convention on Climate Change, the Global Environment Facility's role is defined as "an operating entity of the financial mechanism" for the Convention under Article 11.

[b] Since 1991, approximately US $1.8 billion has been provided in grants from the Global Environment Facility Trust Fund to climate-change activities. An additional amount of more than US $9 billion has been leveraged through co-financing from bilateral agencies, recipient countries, and the private sector.

[c] The Strategic Priority for Adaptation is an ecosystem-focused fund aimed at ensuring that climate change concerns are incorporated in ecosystem management through Global Environment Facility focal area projects. The Strategic Priority for Adaptation finances demonstration projects to show how climate change adaptation planning and assessment can be practically integrated into national policy and sustainable-development planning.

[d] At the first pledging meeting of potential donors to the Special Climate Change Fund, a total of US $34.7 million was pledged. To date, funding windows a and b of the Special Climate Change Fund are active, for a total of $260 million but no pledges have been made to financing windows c and d. The Least Developed Countries Fund now totals $605 million, as of March 28, 2013 (B. Biagini, personal communication, January 12, 2013).

conducted for specific countries. For example, Tompkins et al. (2010) undertook an analysis of adaptation actions in the United Kingdom, Tompkins (2005) looked at adaptation in the Cayman Islands, and Ford et al. (2010) explored adaptation activities within the Inuit population in Canada. What makes this article unique is that it provides the first substantial compendium of experience from adaptation activities implemented through financing from three of the Global Environment Facility mechanisms, thereby providing a snapshot of adaptation activities happening in developing countries from around the world.

4. Methods

To understand how on-the-ground adaptation efforts relate to theoretical typologies of adaptation activity, we reviewed 92 projects in 70 countries within the Global Environment Facility adaptation-funding portfolio. This analysis is limited to adaptation funds created and administered under the UN Framework Convention on Climate Change. Specifically, we reviewed projects financed through the Least Developed Country Fund, the Special Climate Change Fund, and the Strategic Priority for Adaptation. This was accomplished through document analysis, online surveys, and phone/Skype interviews in combination with a review of existing literature on adaptation activities (discussed in Section 2). Our analysis does not include another adaptation fund with a shorter operational history, the Adaptation Fund, created under the Kyoto Protocol with its own Board and governance (although also supported by the GEF). A modified Grounded Theory Method was used to create a typology of adaptation activities being implemented with Global Environment Facility adaptation funds. The Grounded Theory Method, originally developed by Glaser and Strauss (Glaser and Strauss, 1967), is a methodological tool that employs a discovery process where data is used in an inductive way to identify categories, concepts, properties, and interrelationships within a data set, in contrast to starting with a theoretical construct that is tested against the literature (Glaser, 1994). The method has recently evolved into the "Constructivist Grounded Theory" method that acknowledges an approach that is neither purely inductive nor formulaic (Charmaz and Bryant, 2010). The Constructivist Grounded Theory takes a "middle ground" approach through a collaboration that involves the researchers and the informants co-developing knowledge through an iterative, informed process (Bryant, 2002; Mills et al., 2006). As part of the modified Grounded Theory Method, we utilized the adaptation typology literature (Section 2) as a way to theoretically ground the typology development in existing adaptation scholarship (Thornberg, 2012).

4.1. Document analysis

The first phase of the analysis was the coding of project documents within the Least Development Country Fund, the Special Climate Change Fund, and the Strategic Priority for Adaptation of the Global Environment Facility portfolio. Projects were identified by their level of maturity in order to review projects that were far enough along in the implementation phase to have adaptation actions "on the ground." We identified the Global Environment Facility "CEO Endorsement Requests" as the best document type to analyze because it: (a) indicated project approval and maturity; and (b) provided the highest quality and quantity of project data on adaptation actions for each Global Environment Facility project in a consistent format. All available CEO Endorsement Requests, a total of 92 documents, were coded with an open coding approach using Atlas.ti qualitative data analysis software. The breakdown of the CEO Endorsement Requests by Global Environment Facility fund were:

1. Special Climate Change Fund: $N = 26$
2. Least Developed Countries Fund: $N = 41$
3. Strategic Priority for Adaptation: $N = 25$

In total, more than $340 million was allocated by the Global Environment Facility to the 92 projects analyzed. Figs. 1 and 2 show the number of projects by region as well as the amount of Global Environment Facility funding by region across all projects analyzed. Figs. 3–5 show the amount of Global Environment Facility funding allocated geographically by each of the three funding mechanisms. In total, the Least Developed Country Fund allocated roughly $129.8 million to the 41 projects analyzed; the Special Climate Change Fund allocated $96.9 million to the 21 projects analyzed from this fund; and the Strategic Priority for Adaptation allocated $114 million to the 25 projects we reviewed that received funding from this mechanism. The smallest amount of Global Environment Facility financing provided for the projects we analyzed was just over $700,000 for a global project through the Strategic Priority for Adaptation. The highest amount of Global Environment Facility financing provided in the projects we analyzed was just over $11 million for a regional project in Latin

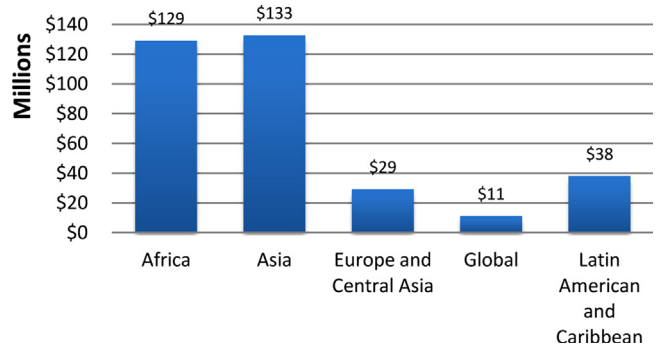

Fig. 2. Total GEF funding allocated by region.

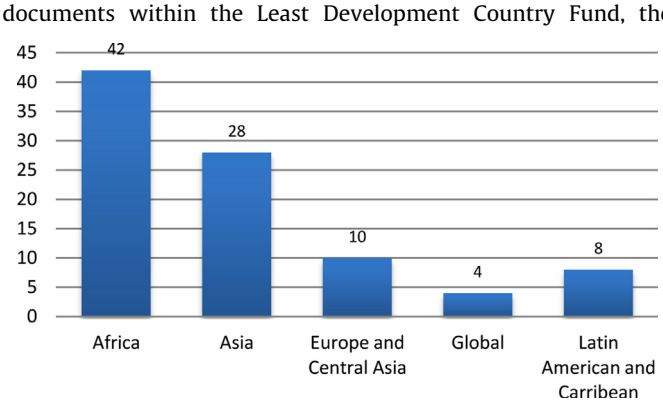

Fig. 1. Total projects examined by region.

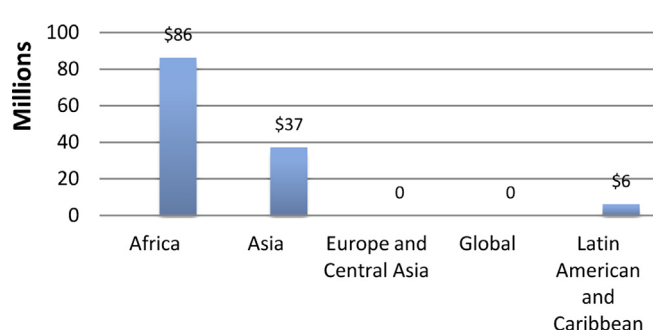

Fig. 3. Total least developed country fund financing allocated by region.

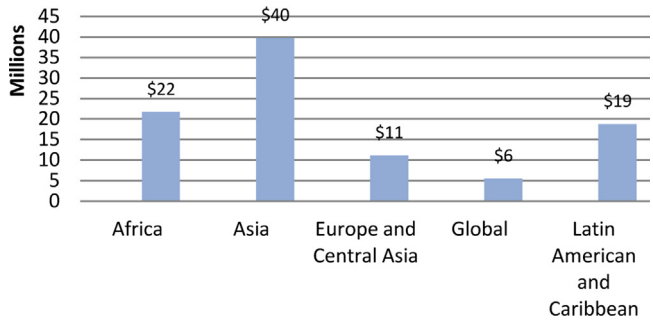

Fig. 4. Total special climate change fund financing allocated by region.

America and the Caribbean through the Strategic Priority for Adaptation.

For the document coding, we extracted the outcomes and outputs specifically identified in the "project results framework" section from each CEO Endorsement Request. We then looked for unique adaptation actions within the outcomes and outputs text. Using Atlas.ti, we identified themes, concepts, and patterns in the data by using inductive coding, which converted complex volumes of narrative text into nominal variables. Once all of the documents were coded, using a combination of peer-reviewed literature and expert judgment we grouped the codes into "families" of like adaptation actions, which gave us a broad, higher order adaption typology. We performed numerous analyses including queries, code groundedness (number of types of code was referenced across documents) code co-occurrences, and network analysis, allowing us to visualize links and relationships between variables (Miles and Huberman, 1994). Next we created code reports and code family network diagrams for each sector and type of adaptation action to look for fundamental similarities and differences in sector typologies in terms of "groundedness" (i.e., how often particular adaptation actions occurred in each sector adaptation type). Initially, 137 unique codes were identified (all codes related to conducting a vulnerability or risk assessment were removed since these were considered precursors to climate adaptation action), which were then organized into categories based on the adaptation typology literature as well as an iterative process within the research team (see supplemental details for a full list of codes).

In order to both verify and refine the draft typology, we conducted a series of surveys and in-depth phone interviews with project leads across the various regions and sectors covered in the Global Environment Facility financed projects. Survey and interview questions were developed to elicit "on the ground" adaptation actions directly from the project implementers. Liaisons from all 92 projects were sent an online survey via Global Environment Facility Adaptation Task Force members, which includes representatives from each Global Environment Facility Agency: Africa Development Bank, Asian Development Bank, Inter-American Development Bank, European Bank for Reconstruction and Development, Food and Agriculture Organization, International Fund for Agricultural Development, United Nations Development Program, United Nations Environment Program, United Nations Industrial Development Organization, and the World Bank. Surveys comprised a series of multiple choice questions based on the initial coding and typology development, followed by a set of short open-ended questions where the informant had the opportunity to add any additional adaptation actions not accounted for in the multiple choice section. A total of 32 distinct surveys were completed (survey and interviews questions can be found in supplemental materials).

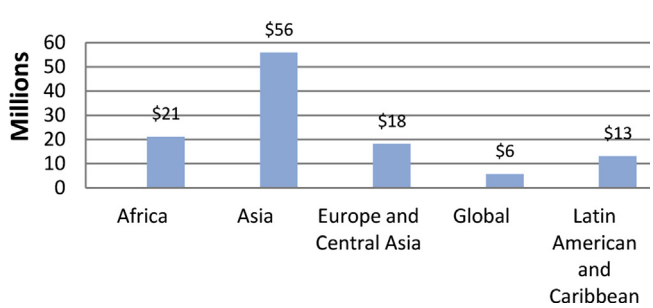

Fig. 5. Total strategic priority for adaptation financing allocated by region.

Interviews followed a semi-structured format with a set of open-ended questions designed to allow the informant to say in their own words, what types of adaptation actions were being implemented in their project. Informants selected for interview were required to be a local practitioner who was or is involved in the implementation/design of the project who can communicate well in English. Should this not be possible (for example, the local practitioner cannot speak English), an implementing agency staff from the country office who is directly involved in the project implementation/design will be selected.

A total of nine interviews with stakeholders were conducted by Skype and phone. Interviews were audio recorded, transcribed, and coded. Coding of phone and online survey results was performed using Atlas.ti to further develop and refine the typology. After the addition of the interviews and surveys, an additional 21 adaptation actions were identified for a final list of 158 distinct adaptation actions. We integrated the new actions into Atlas.ti and then, through an iterative review of all strategies, grouped them into categories of adaptation types. In total, we analyzed 133 documents through a combination of CEO Endorsement Requests, interview transcripts, and survey responses.

5. Results

Based on our analysis, we identified 158 distinct adaptation activities that were grouped into ten overarching categories of adaptation actions, known as the adaptation typology (Fig. 6 and Table 3): Human or Social Resources or Capital (Capacity Building); Governance and Institutional Management and Planning (Management and Planning); Changes in or Expansion of Practice or Behavior (Practice or Behavior); Governance and Institutional Policy Reform (Policy); Information and Communications Technology (Information); Climate-Resilient Physical Infrastructure Adaptations (Physical Infrastructure); Early Warning Systems or Global Climate Observing Systems (Warning or Observing Systems); Climate-Resilient Biophysical or "Green" Infrastructure (Green Infrastructure); Adaptation Related Financial Strategies (Financing); Expansion or Introduction of Climate Adaptation-Related Technology (Technology).

Of all the adaptation activities coded, the majority fell within the *Capacity Building*, the *Management and Planning*, and the *Practice or Behavior* categories (Table 3). Definitions for each code category can be found in Table 5 (second column) along with examples of the codes in each category (third column).

The most frequently coded adaptation actions were those related to *Capacity Building*, *Management and Planning*, and *Policy*. Table 4 shows the top ten adaptation actions out of the 158 based on their groundedness (number of times they appeared in all of the Global Environment Facility financed adaptation projects). The top seven actions in terms of groundedness are all capacity building, which was a component in nearly all the Global Environment Facility financed projects. Overall, the *Practice or Behavior* and the *Capacity Building* category contained the most discrete adaptation actions (34).

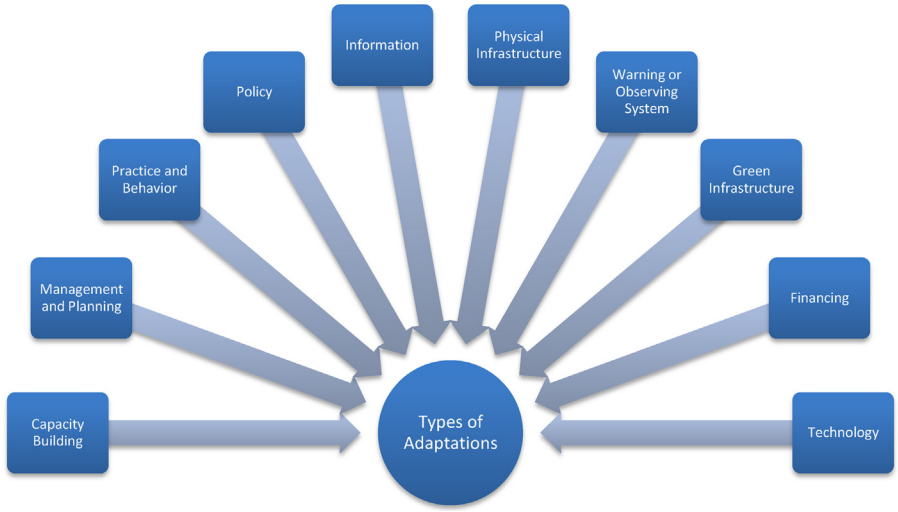

Fig. 6. Categories of adaptation activities from analysis of global environment facility adaptation funds.

A key goal of our analysis was to understand how theoretical frameworks of adaptation typologies compare to real-world adaptation activity. A good deal of the theoretical work on adaptation typology development to-date has been sector-specific, such as analyzing adaptation activity in the agriculture (Smit and Skinner, 2002) or transportation sectors (Eisenack et al., 2012). Another more conceptual area of typology development deals with issues of temporal or spatial scales, scales of governance, and incremental or transformational adaptation activities (Kates et al., 2012; Pelling, 2011; Smit et al., 2000; Smit and Pilifosova, 2001; Smithers and Smit, 1997). In general, the adaptation typology literature has so far relied primarily on theoretical approaches more than on empirical data. In addition, the literature on climate adaptation is heavily weighted toward discussion of methodologies and procedures for vulnerability assessments and policy issues related to governance, compared to the implementation of concrete adaptation actions.

While existing categorizations of adaptation actions have helped to understand the form of adaptation, more information is needed to ground-truth these theoretical classifications with on-the-ground adaptation activities (Eisenack and Stecker, 2012; Tompkins et al., 2010). To advance this concept, we compared our Global Environment Facility-financed adaptation typology with the literature summarized is Section (Table 5). To conduct this comparison, we aggregated the categories of adaptation actions within the literature based on form, and found the following general classifications: administrative/institutional/organizational, behavioral, educational, financial, legal/legislative, market mechanisms, managerial, political, practical, regulatory, research and/or development, structural/infrastructural, and technological (Burton et al., 1993; Carter et al., 1994; Fidelman et al., 2013; Huq et al., 2003; Smit et al., 2000; Smit and Pilifosova, 2001; Smit and Wandel, 2006; Smithers and Smit, 1997; Wilbanks and Kates, 1999).

Through this comparison, we see that a bottom-up assembly of adaptation categories across the Global Environment Facility-funded projects matches well with the groupings identified by the more theory-based peer-reviewed literature. Most projects we examined had combinations of the 10 categories in our typology, with capacity building being present in virtually all projects, and some form of planning/management or improved practices appearing in most projects as well. Many existing typologies break out capacity building into several sub-categories; for example, Tompkins et al. (2010) had 6 such categories. Information systems, early warning systems, infrastructure, and new technologies are listed separately in our typology, which allows identification of the kind of technology being put in place by the project. While some typologies might have 'lumped' these categories into one larger bucket (Eisenack et al., 2012; Smit and Skinner, 2002; Ayers and Huq, 2009), the Global Environment Facility documents differentiated among these kinds of actions,

Table 3
Groundedness of adaptation typology by category.

Adaptation typology	Number of occurrences in Global Environment Facility texts (groundedness)
Capacity building	1310
Management and planning	474
Practice or behavior	409
Policy	268
Information	219
Physical infrastructure	178
Warning or observing systems	170
Green infrastructure	99
Financing	76
Technology	49

Table 4
Top ten adaptation actions based on groundedness.

Adaptation actions	Groundedness (frequency in Global Environment Facility portfolio)
Training/workshops for knowledge/skills development	230
Public Education and Outreach Strategy/Campaign	153
Identification and dissemination of best practices/lessons learned	142
Dissemination of info to decision makers/stakeholders/managers	142
Creation of training materials/ capacity building tools	127
Creation/support of organizations or networks of people	102
Policies developed or revised	94
Prepare information or communication tools	90
Development of an adaptation or adaptive management plan	87
Monitoring project	86

Table 5
Typology of climate adaptation action.

Adaptation category	Description	Examples of actions in category	Similar classification in literature
Capacity Building	Developing human resources, institutions, and communities, equipping them with the capability to adapt to climate change	Training/workshops for knowledge/skills development, public outreach and education, dissemination of info to decision makers/stakeholders, Identification of best practices, training materials	Educational/informational (Smit and Skinner, 2002; Wilbanks and Kates, 1999; Huq et al., 2003; Smit et al., 2000; Carter et al., 1994; Tompkins et al., 2010)
Management and Planning	Incorporating understanding of climate science, impacts, vulnerability and risk into government and institutional planning and management	Developing an adaptation plan, livelihood diversification, drought planning, coastal planning, ecosystem-based planning, changing natural resource management	Administrative/institutional/organizational (Smit and Skinner, 2002; Wilbanks and Kates, 1999; Huq et al., 2003; Smit et al., 2000; Carter et al., 1994; Tompkins et al., 2010)
Practice and Behavior	Revisions or expansion of practices and on the ground behavior that are directly related to building resilience	Soil/land management techniques; climate-resilient crops or livestock practices, post-harvest storage, rainwater collection, expanding integrated pest management	Behavioral (Smit and Skinner, 2002; Wilbanks and Kates, 1999; Huq et al., 2003)
Policy	The creation of new policies or revisions of policies or regulations to allow flexibility to adapt to changing climate	Mainstreaming adaptation into development policies, land-use specific policies, improvement of water resource governance, revised design parameters, ensuring compliance with existing regulations	Legislative/Legal (Smit et al., 2000; Carter et al., 1994)
Information	Systems for communicating climate information to help build resilience towards climate impacts (other than communication for early warning systems)	Decision support tools, communication tools, data acquisition efforts, digital databases, remote communication technologies	Infrastructural/structural (Smit et al., 2000; Carter et al., 1994) Educational/informational (Smit and Skinner, 2002; Wilbanks and Kates, 1999; Huq et al., 2003; Smit et al., 2000; Carter et al., 1994)
Physical infrastructure	Any new or improved hard physical infrastructure aimed at providing direct or indirect protection from climate hazards	Climate-resilient buildings, reservoirs for water storage, irrigation systems, canal infrastructure, sea walls	Infrastructural/structural (Smit et al., 2000; Carter et al., 1994)
Warning or observing systems	Implementation of new or enhanced tools and technologies for communicating weather and climate risks, and for monitoring changes in the climate system	Developing, testing and deploying monitoring systems, upgrade weather or hydromet services	Research and development (Smit et al., 2000; Carter et al., 1994)
"Green" infrastructure	Any new or improved soft, natural infrastructure aimed at providing direct or indirect protection from climate hazards	Revegetation, afforestation, woodland management, increased landscape cover	Infrastructural/structural (Smit et al., 2000; Carter et al., 1994)
Financing	New financing or insurance strategies to prepare for future climate disturbances	Insurance schemes, microfinance, contingency funds for disasters	Financial (Smit and Skinner, 2002; Wilbanks and Kates, 1999; Huq et al., 2003; Smit et al., 2000; Carter et al., 1994) Market mechanisms (Smit et al., 2000; Carter et al., 1994)
Technology	Develop or expand climate-resilient technologies	Technologies to improve water use or water access, solar energy capacity, biogas, water purification, solar salt production	Technological (Smit and Skinner, 2002; Wilbanks and Kates, 1999; Huq et al., 2003; Smit et al., 2000; Carter et al., 1994)

which can serve different goals in achieving sustainable, climate-prepared development. Thus, tracking more detail on technological projects going forward may be warranted.

6. Discussion

The ten categories identified in our typology are based on real-world adaptation projects being financed through the Least Developed Countries Fund, the Special Climate Change Fund, and the Strategic Priority for Adaptation. This analysis demonstrated that many of the early ideas and concepts surrounding adaptation typologies advanced by theoreticians are consistent with results from the field. The typology derived from this analysis of concrete projects provides a framework to compare and analyze theoretical and real-world adaptation activities.

While this analysis was unable to conduct on-site review of projects, through the use of project documentation, surveys, and interviews, the analysis was able to provide insight into what local stakeholders perceive as critical adaptation actions to help build resilience to a variety of climate-related impacts. The intent of the research was to derive a higher-order typology of real-world adaptation actions in order to help reconcile theoretical typologies with on-the-ground adaptation experience (Table 5). The majority (93%) of the 158 distinct adaptation actions clearly fit within one of the ten proposed categories of our adaptation typology. There were, however, approximately 7% of the adaptation actions identified that could be classified under more than one category.

A preponderance of activities coded as part of this analysis fall under the auspices of capacity building. This is understandable as vulnerable countries and communities cannot start implementing certain types of adaptation actions until they have created an enabling environment. As the capacity baseline of each country varies significantly, so does the type of capacity building activity (or activities) that is needed for each individual project. It is also worth noting that the categories in the typology that are non-capacity building actions represent activities that are generally

more expensive than capacity building. The groundedness of capacity building within the typology is consistent with Ayers and Huq (2009) and Tompkins et al. (2010) who identify capacity building as one of the primary activities needed in developing countries to help prepare for climate change.

The importance of capacity building activities was further substantiated through the interviews and surveys with project managers. Respondents emphasized the importance of capacity building and the role that Global Environment Facility financing has played in supporting these efforts. Moreover, most respondents emphasized the importance of an end-to-end participatory, community-based approach in all phases of the projects. This has implications from problem/vulnerability/impact/risk identification to context-specific selection and prioritization of adaptation actions. As such, respondents reported that projects served to facilitate a learning process in which the project managers worked with communities to identify adaptation actions that would feasibly meet community needs in ways that are culturally and politically salient. Informants repeatedly emphasized that, while the science is important as a guide, ultimately what *works* and is likely to be successfully implemented to a large degree depends on the communities themselves and their awareness and willingness to act.

Another result confirmed by practitioners through interviews and surveys is that adaptation actions being implemented were selected to specifically respond to vulnerabilities identified during the preparatory stage of the project. This reinforces and helps validate the claim that adaptation actions identified in the typology represent concrete actions that can, under the right circumstances, reduce vulnerability and increase adaptive capacity of people, sectors, and communities that are impacted by climate change. This result explicitly shows the link between theory and practice, by showing that a scientifically sound, theoretical approach to vulnerability and adaptation assessments can lead to the identification and implementation of actions that specifically respond to identified vulnerabilities.

The development of the adaptation typology was mainly focused on the identification of concrete adaptation actions that are desired by countries/regions, and not on the costs of adaptation. Indeed, many projects had substantial co-financing, such that overall expenditures could be many times that coming from the Global Environment Facility. Therefore, no specific attempt was made to determine the relative costs of adaptation activities within projects. However, the analysis conducted as part of this project provide valuable insight for researchers and funding agencies with regard to differences between climate adaptation and business-as-usual development activities. To receive funding from the Global Environment Facility, the activities identified by the typology need to include "uniquely adaptation" actions, meaning that, traditionally, they would not be financed as part of business-as-usual development assistance. Going forward, being able to characterize which types of actions, and which categories of actions are most identified by countries as needed to advance adaptation, is crucial. Being able to track how this information changes over time both within and across countries will begin to build the long-term database needed to identify best practices and lessons learned. In the future, more analysis of the goals of the co-financing monies and the composite outcomes may help illuminate ways to achieve multiple benefits and reduce multiple stresses while enhancing sustainable, climate-resilient development. Finally, analysis of outcomes when these projects are completed, and tracking the permanence of these outcomes will become an important database to help funding agencies and governments enable the integration of climate adaptation considerations into conventional development assistance.

Another insight that emerged during the typology development was that the adaptation categories that have the highest groundedness are those that contain projects with "soft" measures, such as those related to capacity building, policy reform, and planning and management. Traditionally, these measures are low-cost. On the other hand, less recurrent categories of adaptation activities, such as those under the categories of technology, physical infrastructure, and early warning systems, are less frequent but could be more expensive and therefore, need careful design to insure efficacy and efficiency in the use of financial resources. For instance, in a Global Environment Facility project to address climate change risks from glacial lake outburst floods in the Puhakha-Wangdhi and Chamkhar Valleys of Bhutan, less than 9% of funding went to policy analysis and capacity building, and less than 1% went to knowledge management. By contrast, slightly over 66% of the grant was allocated to the engineering and construction of infrastructure for artificially lowering the lake, and 24% of the grant was allocated to creation of an early warning system (Global Environment Facility, 2013). In another example, from a project in the Maldives with a focus on protection from sea-level rise and flooding, a little over 8% was dedicated to capacity building, less than 4% to knowledge management and learning, and 23% dedicated to "Policy Support" (Global Environment Facility, 2013). However, nearly 65% of the funding was allocated to infrastructure investments, including coastal protection measures for flooding and erosion. These results indicate that a future analysis of the cost of various adaptation activities identified in the typology will likely help provide further refinement to the relative importance of the various adaptation actions as opposed to simply relying on groundedness figures. Unfortunately, the CEO Endorsement Requests forms that were used for this analysis do not provide specific financial details for each of the adaptation actions proposed in a given proposal, meaning that this type of analysis was not possible at this time.

As the largest collection of maturing adaptation projects, the Global Environment Facility project database reveals a representative picture of modern adaptation activities in the developing world. As such, it is hoped that the typology presented in this paper will provide insight into what adaptation is in practical terms and how researchers and development agencies can support it on the ground. The typology could be instrumental in measuring results when these projects are completed, including the selection of indicators most likely to be appropriate to gauge adaptation success per category in the typology. Understanding the types of adaptation actions is a key prerequisite for determining the appropriate indicators for measuring results of adaptation actions. As adaptation financing is a relatively new process, adaptation results-based management and monitoring and evaluation systems are still a work in progress that will significantly benefit from a rigorous identification of adaptation types.

Lastly, it is also possible that the adaptation typology combined with the groundedness of specific actions is a reflection on the evolution of adaptation activities. For instance, capacity building, the most grounded category, is also frequently the first step of an adaptation process. Therefore, the higher percentage of capacity building activities may be reflective of the novice stage of overall societal adaptation or of the prevalence of barriers that first must be grappled with before adaptation can be actuated. By contrast, technology, per se, is the least-grounded category in this typology, and, indeed, given the rising demand for adaptation technology, we predict that this category will grow dramatically over the long term. Overall, the relative groundedness of individual categories is expected to change as the climate adaptation field and the need of local stakeholders evolves. Additionally, as more adaptation projects are implemented, we are likely to continue seeing more new unique kinds of adaptation actions, some of which may be

more discrete subsets of the current types identified. Therefore, over time, the development of this taxonomy of adaptation actions may lead to a more fine-grained understanding of adaptation in its full spectrum. As such, the typology should continue to evolve, especially as new categories of adaptation actions are developed, or as old types of adaptation actions are further subdivided.

While our intent is to explore various classifications of adaptation form, it is worthwhile to note the work of authors such as Yohe et al. (2011), Agrawala et al. (2011), Hall et al. (2012), and Smith et al. (1996) who have done considerable work exploring and classifying the timing of adaptation actions. In a recent paper by Felgenhauer and Webster (2013), the authors, building off of previous work, create a three-part typology to classify adaptation actions based on the timing of action: "short-lived flow spending; long-lived and committed adaptation stock; and less costly option stock that allows for later adaptation capacity upgrading if and when needed (p. 4)." Within this typology, flow spending tends to be low-cost, quick to implement and return benefits, but limited in the level of damages that can be avoided. Adaptation stocks are investments that are long-lived, traditionally large-scale with high costs with benefits existing over a long period of time, but depreciating over time. The third option, adaptation option stock is defined as "initial investments in preparatory adaptation with a lower adaptive capacity which enables easy expansion in the future if it is needed to address rising climate damages" (Felgenhauer and Webster, 2013: 5). Future analysis of adaptation actions within the Global Environment Facility database (and others) should consider timing, and how flexible or robust actions taken in the face of a changing climate are. Investments will need to have both short-term and long-term benefits, and balancing near-term expenditures with long-term outcomes is important.

7. Conclusion and next steps

This article shares ten years of operational experience built through the implementation of adaptation projects around the world in an effort to begin to unite empirical data with the ongoing academic discussion on climate adaptation activities. Using a Grounded Theory Method, researchers analyzed 92 adaptation projects financed under the Least Developed Countries Fund, the Special Climate Change Fund, and the Strategic Priority for Adaptation. The resulting analysis identified 158 unique adaptation actions falling within 10 broad categories, which form the adaptation typology presented here.

By integrating empirical data with existing theoretical frameworks and categorization of adaptation actions, a more solid understanding of what adaptation is, in practice, has emerged. The insights gleaned from this analysis can enrich the quality of the academic discussion on adaptation to climate change while simultaneously shedding light into how funding agencies are supporting on-the-ground adaptation efforts. Additionally, this study demonstrates that significant emphasis is still needed for capacity building activities, especially to the extent they serve as pre-requisites for more advanced adaptation activities.

Given that this is an initial exercise to combine adaptation categories across sectors and regions with empirical data distilled from the operation of the Global Environment Facility portfolio, additional work will be needed to update the adaptation typology as new measures get financed and as projects move into more advanced phases of implementation. Additionally, a more detailed analysis of the specific costs of adaptation actions could be conducted to determine the costs per adaptation activity that the Global Environment Facility allocates resources to. An analysis of this kind could also explore the relative costs of each adaptation action, effectively serving as a basis for any assessments of effectiveness of the adaptation measures adopted, including cost-effectiveness.

Another area of needed research is examining how the distribution of actions and their costs change between project design and implementation. Such an analysis of planned versus actual adaptation actions and planned costs versus actual costs would be of immediate practical use to practitioners and donors alike. As more projects reach the end of implementation, these kinds of analyses will become increasingly feasible.

To date, the peer-reviewed literature has been heavily biased towards analysis of vulnerability assessments and understanding climate impacts. As growing numbers of communities move forward with implementing adaptation measures, researchers should begin collaborating with these "local adaptation laboratories" for further studies and analysis. For example, the Asian Cities Climate Change Resilience Network, the Climate-Resilient Communities program organized by ICLEI, and the C40 all present opportunities for researchers to engage with local practitioners to understand how adaptation activities are being designed, implemented, and evolving on the ground. One such example is a new effort, "the Learning Route" which is enabling researchers and local policymakers to learn from practitioners in four African countries to improve adaptation projects and policy design (Scientific and Technical Advisory Panel, 2010).

Recent work reviewing the Global Environment Facility has encouraged more linkage of the practitioner world to the academic literature. For example, Redford and Huntley (2013) note: "There is little evidence that the mainstreaming projects funded through Global Environment Facility have produced peer-reviewed articles written either by the project implementers or by others. . .There is an obvious and important need for the practitioners of mainstreaming to publish in the peer-reviewed literature."

Going forward, the Global Environment Facility has defined "strengthening results and knowledge management" as a key goal in their draft 2020 Strategy Paper (Global Environment Facility, 2013). A recent report advised that current projects are not taking full advantage of the opportunities to expand the evidence base through deliberate project design. Using information gleaned from current project designs, the intended actions, and the ultimate outcomes can inform future project design and enhance efficiency and efficacy of adaptation projects. Moreover, monitoring and evaluation of ongoing projects, and the identification of metrics for success are key next steps to improve adaptation efforts in both the theoretical and empirical realm.

In closing, further comparative analysis between the adaptation typologies identified by theoreticians and the adaptation typology identified by examining concrete adaptation projects will further an important and much needed harmonization between theory and practice. The good news is that 'a thousand flowers are blooming' and that adaptation projects are burgeoning; the opportunity is that 'lessons learned' and 'best practices' must still be gleaned, summarized, and made available to inform the next generation of adaptation projects.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.gloenvcha.2014.01.003.

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