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ORIGINAL ARTICLE

How are we adapting to climate change? A global assessment

Alexandra C. Lesnikowski · James D. Ford · Lea Berrang-Ford · Magda Barrera · Jody Heymann

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Abstract This paper applies a systematic approach to measuring adaptation actions being undertaken by 117 parties to the United Nations Framework Convention on Climate Change (UNFCCC) with the goal of establishing a baseline of global trends in adaptation. Data are systematically collected from National Communications prepared by Parties to the Convention and submitted periodically to the Secretariat. 4,104 discrete adaptation initiatives are identified and analyzed. Our findings indicate that while progress is being made on conducting impact and vulnerability assessments and adaptation research in nearly every country in the sample, translation of this knowledge into tangible adaptation initiatives is still limited. The largest number of reported adaptations falls under the category of infrastructure, technology, and innovation. Some types of vulnerability were more frequently reported across initiatives, including floods, drought, food and water safety and security, rainfall, infectious disease, and terrestrial ecosystem health. Notably, reporting on the inclusion of vulnerable sub-populations is low across all actions. Diffusion of adaptation across sectors remains underdeveloped, with the environment, water, and agricultural sectors emerging as the most active adaptors. Our analysis indicates that national communications provide a valuable source of information for global-scale adaptation tracking, but important gaps exist in the consistency of reporting that

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A. C. Lesnikowski · J. D. Ford · L. Berrang-Ford
Department of Geography, McGill University, 805 Sherbrooke St West, Montreal, QC, Canada H3AOB9

M. Barrera · J. Heymann
Institute for Health and Social Policy, McGill University, 1130 Pine Avenue West, Montreal, QC, Canada H3A1A3

Present Address:
A. C. Lesnikowski (✉)
School of Community and Regional Planning, University of British Columbia, #433-6333 Memorial Road, Vancouver, BC, Canada V6T1Z2
e-mail: alesnikowski@gmail.com

Present Address:
J. Heymann
Fielding School of Public Policy, University of California Los Angeles, 650 Charles E. Young Dr S, Los Angeles, CA 90095, USA

should be addressed, as these documents could greatly enhance efforts to monitor and evaluate adaptation progress.

Keywords Adaptation · Climate change · Systematic review · Tracking adaptation progress · UNFCCC

1 Introduction

It is now widely accepted that the climate is changing. Recent modeling studies indicate that global temperatures will increase in excess of two degrees Celsius over the next century, with four degrees of warming viewed as increasingly likely (Hansen et al. 2012; Rogelj et al. 2011). Recent evidence from the United Nations Intergovernmental Panel on Climate Change (IPCC) indicates that these changes will have significant implications for extreme weather events, development, economic stability, and population and ecological health (IPCC 2012). While mitigation efforts remain critical to reducing the magnitude of future climate change, a simultaneous focus on adaptation is essential given the recognition that we are locked into some degree of climate change (Costello et al. 2009, 2011; Ford et al. 2010; Ford and Berrang-Ford 2011; Parry et al. 2009; Pielke et al. 2007).

With the creation of new finance instruments for adaptation and expected increases in the availability of funding, investment in adaptation research and implementation is growing both in developed and developing countries (Global Environment Facility 2012; Berrang-Ford et al. 2011; Ford et al. 2011a, b; Porter et al. 2008). As adaptation financing increases and initiatives begin entering later stages of development, the need for tools that track progress on adaptation is becoming more pronounced (Brooks et al. 2011; Ford et al. In Press; Lesnikowski et al. 2013). The Notre Dame-Global Adaptation Index (ND-GAIN), for example, ranks countries by vulnerability to climate hazards and readiness to adapt to climatic changes with the goal of guiding public and private sector investment in adaptation. The index does not, however, measure the status of adaptation already being implemented. The global climate risk index and climate change vulnerability index similarly measure exposure and sensitivity to extreme climatic events. The environmental sustainability index differs from these indices in that it ranks countries based on fulfillment of environmental policy goals, but does not directly measure climate change adaptation (Brooks et al. 2011; Preston et al. 2009, 2011).

Several studies have examined progress on adaptation across countries, notably Gagnon-Lebrun and Agrawala (2007), who assess broad trends in the implementation of adaptation across high income countries and find limited evidence of anticipatory adaptation at the point of implementation. A 2009 report released by the partnership for European environmental research conducts a comparative analysis of national adaptation strategies among 11 European countries, assessing similarities and differences in approaches and knowledge gaps (Swart et al. 2009). Other analyses have assessed adaptation action within a specific country (Bierbaum et al. 2013; Tompkins et al. 2010) or region (Ford and Pearce 2010), and within particular sectors (Ford et al. 2011b, c; Pearce et al. 2011; Eisenack et al. 2012). Analyses of adaptation progress across countries have been conducted among higher-income countries (Ford et al. 2011a; Lesnikowski et al. 2011).

In addition to this research, several inter-governmental organizations have launched initiatives to develop adaptation inventories. The United Nations Development Program (UNDP), for example, maintains the adaptation learning mechanism, and the United Nations Framework Convention on Climate Change (UNFCCC) has a database on local coping strategies, providing a forum for stakeholders to share knowledge about best practices (UNDP; UNFCCC). The

European Environment Agency (EEA) has launched the European climate adaptation platform to compile information about adaptations occurring within European countries and transnational regions (EEA). These inventories provide valuable information about good practices and adaptation experiences. Notwithstanding these emerging efforts, there are significant gaps in our understanding of the status of adaptation globally. The state of global adaptation tracking beyond case-studies and theory remains limited. Much of the work to-date has focused on project-level initiatives, frequently led by development agencies, identifying gaps in actions and policies, profiling lessons learned, and exploring the unique challenges posed by adaptation (Lamhauge et al. 2012; Spearman and McGray 2011; Villaneuva 2011; Mckenzie Hedger et al. 2008).

This gap in understanding provides context for this paper, which aims to establish a baseline understanding of adaptation currently being pursued globally. Our analysis aims to: i) systematically assess national policy documents to create a baseline of national adaptation initiatives, ii) compare adaptation progress among nations, and iii) characterize adaptation actions. The analysis herein uses the only global set of standardized adaptation information currently available, the national communications to the UNFCCC, to characterize adaptation efforts across high, medium, and low income countries.

To our knowledge, this is the largest comparative study on climate change adaptation, and differs from existing work in several ways, including an emphasis on quantifiable variables that are available for a large number of countries, the use of systematic approaches to data collection and analysis, and a focus on adaptation actions or responses rather than indices of vulnerability or risk. Based on this analysis, we conclude with a discussion about the nature and quality of adaptation information available on a global level, and make recommendations for improving the data available for global adaptation tracking.

2 Methods

The methodology applied in this analysis expands on the systematic approach of Lesnikowski et al. (2011) to characterize and compare adaptation outcomes among 117 countries submitting national communications to the UNFCCC. We select national communications from the UNFCCC, then extract and code adaptation initiatives reported within. We collect a comprehensive database of adaptation initiatives from across 117 countries from which we characterize the global state of adaptation by the nature of adaptation initiatives being reported, vulnerabilities provoking adaptive responses, stakeholder involvement in policies and programs, and consideration of vulnerable groups. Our analysis is aided by the calculation of a basic Adaptation Initiatives Index, which ranks countries based on the range of adaptation actions reported through the national communications.

2.1 Data source

The national communications submitted to the UN FCCC were identified as the most appropriate data source for tracking adaptation because of their global scope, reliable submission intervals, and efforts at consistency in content (Gagnon-Lebrun and Agrawala 2007; Lesnikowski et al. 2013; Lesnikowski et al. 2011). There are a total of 195 parties to the UNFCCC (194 countries and the European Union). Signatories are differentiated by treaty commitment, and consist of Annex I, Annex II, and non-Annex I parties.

As official documents submitted by national governments to the UNFCCC secretariat, the communications provide information regarding signatory country's efforts to fulfill the requirements of treaty membership. Nearly every member country of the UNFCCC has submitted at least one national communication, rendering them the most complete data set available on adaptation initiatives provided by national governments. The national communications differ from adaptation planning documents like national adaptation plans and the UNFCCC national adaptation plans of action (NAPAs) because they provide evidence on how resources are being used to further adaptive responses. These other adaptation planning documents provide information on needs, objectives, and priorities, but do not provide complete information on how this has been translated into tangible actions. The national communications are therefore well-suited to an empirical study of adaptation progress.

Communications are drafted according to standardized guidelines provided by the Secretariat, and are prepared and submitted based on timelines determined by the secretariat. Annex I countries are required to submit communications every 4–5 years. The most recent communication was submitted during the 2009–2010 period. Non-Annex I countries are expected to submit an initial communication within 3 years of joining the treaty, or according to the availability of financial resources. Most non-Annex I countries have submitted updated communications since 2008. To reduce the inclusion of outdated information, communications submitted prior to 2008 were excluded from the dataset. A total of 117 countries were included in the analysis, with submission years ranging from 2008 to 2012 (see Appendix A in Supplemental Materials for full list of included countries). Only communications immediately available through the UNFCCC website were included, and those submitted after July 1st 2012 were not included.

Data collected from the national communications provide a proxy sample of adaptations occurring among UNFCCC Parties, and do not reflect a complete inventory of all adaptation efforts. The communications summarize progress on adaptation that national governments consider to be representative of efforts to date across different sectors. It is likely therefore that adaptation actions involving senior levels of government are over-represented in reporting. Herein, our results primarily reflect reporting on global adaptation action that is nationally-led or involves substantive national-level collaboration. Quality of reporting varied across national communications. Minimum levels of information were included in our data inclusion criteria to control for excessively vague language. Indicators were designed to include an indeterminate category for insufficient information. For further details on data inclusion requirements, see Data collection below.

2.2 Data collection

Analysis of the communications aimed to identify and characterize national-level adaptations to climate change. Information was categorized based on 12 indicators. The indicators capture country, communication number, reporting year, action title, vulnerability, level of action, type of action, status of action, implementation approach, actor participation, sector participation, and vulnerable group (see Table 1). The indicators were created to be consistent over time, space, and scale; to be clear, defined, and easily used; and to be based on regularly collected and accessible data (Horrocks et al. 2005). Each row in the database represents a discrete adaptation initiative, with indicators organized by column.

The typology of actions was adapted from Lesnikowski et al. (2011), and classifies initiatives under two possible levels of action: groundwork and adaptation. Groundwork level actions are those initiatives considered critical for informing and preparing for adaptation. Types of action considered to be groundwork level include impact and vulnerability

Table 1 Complete list of indicators guiding data collection

1. Country	Open field	
2. Communication number	Most recently submitted communication: one to five.	
3. Reporting year	Year most recently submitted or revised: 2008 to 2012.	
4. Initiative title	Open field: as identified in the national communication	
5. Vulnerability (Not mutually exclusive)	Options: sea level rise, frozen ground, rainfall, runoff, water quality and quantity, floods, drought, storms, wildfires, erosion / landslides, desertification, food quality and quantity, infectious disease, air quality, extreme heat, extreme cold, mental health, human health (general), marine ecosystem health, freshwater ecosystem health, terrestrial ecosystem health, economic, electricity / telecommunications, displacement / conflict, traditional lifestyles, other (description field provided), indeterminate.	
6. Level(s) of action (Not mutually exclusive)	Options: groundwork, adaptation.	
7. Type(s) of Action (Not mutually exclusive)	Groundwork level action	Options: climate change scenario, impact / vulnerability assessment, adaptation research, conceptual tool, stakeholder networking, policy recommendations.
	Adaptation level action	Options: organizational development, regulation, public awareness / outreach, surveillance / monitoring, infrastructure / technology / innovation, resource transfer / financial mechanisms, review, other (description field provided).
8. Status of action (Mutually exclusive)	Options: recommended, planned, partially complete, complete (ongoing), complete (finished), evaluated, indeterminate.	
9. Approach (Mutually exclusive)	Options: mainstreamed into pre-existing institution(s), autonomous, indeterminate.	
10. Actor(s) (Not mutually exclusive)	Options: international organization / agency, regional organization / agency, government: national, government: sub-national, government: local, CSO (global, regional, national, or local), private sector, university / research group, other (description field provided), indeterminate.	
11. Sector(s) (Not mutually exclusive)	Options: emergency management, infrastructure, health, education, human services, agriculture, water, environment, energy, coastal management, development, national security, forestry, fisheries, transportation, insurance, tourism, economy, culture / arts / heritage, technology, inter-sectoral, other (description field provided), indeterminate.	
12. Vulnerable population(s) (Not mutually exclusive)	Options: elderly, children, chronic / pre-existing condition, indigenous groups, race / ethnicity, language, nationality, religion, sex / gender, sexual orientation, social disability, social position, other (description field provided), none.	

assessments, adaptation research, conceptual tools, climate change scenarios, stakeholder networking, and policy recommendations. Adaptation level actions are understood as initiatives that are implemented to tangibly improve the resilience of human and natural systems. Types of action included under the adaptation level include organizational developments, regulations, infrastructure / technology / innovation, public awareness and outreach, surveillance and monitoring, resource transfers and financial support, and performance reviews of adaptation progress. Every discrete action included in the data set is therefore classified according to both

level of action and type of action. Further details regarding categorization of vulnerabilities based on the findings of Working Group II of the Fourth Assessment Report (AR4) of the IPCC can be found in the Supplementary Materials.

Initiatives included in the dataset are explicitly concerned with the impacts of climatic change, not impacts of general climate processes or weather or sectoral trends. Responses to both positive and negative impacts of climate change were included. Information was required to have a minimum level of detail to be included in the dataset. We required that the type of action be easily identifiable; where information on other indicators was unclear or not provided we recorded the indicator as indeterminate.

Many initiatives are designed and implemented through partnerships between actors within a country and funders or organizers from outside. The goal of this paper is to identify evidence of research, policies, projects, and programs that are aimed at improving the ability of countries to absorb impacts of climate change. As such, all initiatives were included that were documented as occurring within the reporting country. All stakeholders, whether domestic or foreign, reported to be involved in the initiative were recorded under an "actor participation" indicator. The detailed codebook used to guide data collection is available in Appendix B in supplemental materials for further information.

2.3 Data analysis

Our results present a baseline understanding of where adaptation is occurring, the nature of adaptation initiatives being pursued, and which sectors and stakeholders are most engaged in reported adaptation. Results characterizing adaptation initiatives are summarized at a country level. We frequently refer to the number of countries reporting on various components of the variables identified in the previous section. Where trends are particularly noteworthy we also discuss results at the initiative level. Our intention is to provide a basic understanding of the current global state of adaptation.

An Adaptation Initiatives Index was also created to compare adaptation outcomes across countries. Both level and type of action are included in the index calculation. Adaptation actions are weighted 1 or 2 to reflect the distinction between preparatory (groundwork=1) actions and tangible actions that improve community resilience to climate change (adaptation=2). The following equation was used to calculate the adaptation outcomes index:

$$\left(\mathrm{ToA}_{\#\mathrm{GW}} \times 1\right) + \left(\mathrm{ToA}_{\#\mathrm{ADAPT}} \times 2\right)$$

Within this equation, $\mathrm{ToA}_{\#\mathrm{GW}}$ equals the number of types of groundwork action identified in the communication, with a possible number of 0–5 types of groundwork action. $\mathrm{ToA}_{\#\mathrm{ADAPT}}$ equals the number of types of adaptation action identified in the communication. The total possible number of types of adaptation action are 0–7. The possible range of scores is 0–19, with 0 representing no evidence of any response taken to climate change risks and 19 representing demonstrated responses covering all 12 types of action. Leaders in adaptation are identified based on this index, as well as those countries falling behind in adaptation. The number of vulnerabilities addressed by each country is not included in this index. Policy recommendations are considered separately from all other types of action.

3 Results

Countries reported 3395 discrete adaptation initiatives, as well as 709 recommendations for action. Seventy-three percent (n=2996) of initiatives constituted groundwork level action

(including recommendations for action), while 23 % (n=931) contained tangible adaptation actions. Four percent (n=177) of activities overlapped, demonstrating both groundwork and adaptation elements. The majority of communications submitted were second national communications from non-Annex I parties (n=68). All Annex I parties submitted fifth national communications between 2009 and 2010 (n=39).[1] Seven countries (Angola, Bosnia and Herzegovina, Montenegro, Qatar, San Marino, Serbia, Syria) have only submitted a first communication. The number of discrete initiatives and policy recommendations identified per country in the communications range from zero to 177. The median number of initiatives and recommendations is 27.

3.1 Leaders and laggards

The adaptation initiatives index is applied here to facilitate a comparison of adaptation outcomes among the top 10 % of countries included in the data set and the bottom 10 % (herein referred to as leaders and laggards). The most significant difference between leading and lagging countries is a lack of evidence that adaptation is occurring in any laggard countries. Laggards indicate that steps are being taken to complete impact and vulnerability assessments, climate change scenarios, adaptation research, and conceptual tools, but no laggard country reports adaptation initiatives beyond the groundwork level (Table 2). Monaco is particularly notable for receiving a score of zero. Its communication states that nothing has yet been done on vulnerability or adaptation evaluation, and does not indicate that any steps are being planned in the future.

Countries categorized as leaders on the other hand demonstrate substantial evidence of adaptation action. Countries with index score of 17 (Belgium, Canada, Italy, Mexico, New Zealand, Spain, United States, Uruguay) reported on 11 out of 12 kinds of activities (all five categories of groundwork and six of seven categories of adaptation), while countries with a top index score of 19 (Australia, Finland, Saint Lucia, South Korea) demonstrated all 12 types of action.[2]

Both leaders and laggards produced low reporting on vulnerable groups, although reporting was slightly more frequent among leaders. Eight of 12 leaders report on at least 3 kinds of vulnerable groups; Australia has the strongest coverage, reporting on seven out of 11 categories of vulnerable groups. Notably, Saint Lucia reports on zero vulnerable groups despite receiving a top adaptation score of 19. Leaders also demonstrated much stronger evidence of stakeholder engagement in groundwork and adaptation initiatives. Eight leaders report on engaging at least six categories of stakeholders. On the other hand, five laggards only report on actions occurring on a national government level, while a further six also report on initiatives occurring with university and research groups.

Six of 14 laggards report on at least three kinds of vulnerable groups. Several countries stand out among the laggard group with higher reporting levels on vulnerable groups. Montenegro and Togo report actions on five of 11 categories of vulnerable groups, while Lebanon reports on six categories of vulnerable groups. Three countries do not report on any vulnerable group (Monaco, Swaziland, Angola).

3.2 Action remains primary in the groundwork stage, with progress being made on few adaptations

Most of initiatives being reported in the national communications are occurring at a groundwork level (Fig. 1). The majority of activities are impact and vulnerability assessments,

[1] Bulgaria submitted a revised Fifth national communication in 2012.
[2] Note that no country received an adaptation score of 18.

Table 2 Adaptation Initiative Index summarizing leading and lagging countries

Country	Adaptation score	Types of action	Vulnerabilities	Vulnerable groups	Stakeholder involvement
Leaders					
Australia	19	12	21	7	7
Belgium	17	11	21	4	6
Canada	17	11	24	6	7
Finland	19	12	25	3	6
Italy	17	11	24	6	7
Mexico	17	11	20	1	5
New Zealand	17	11	16	1	6
Saint Lucia	19	12	21	0	3
South Korea	19	12	20	3	4
Spain	17	11	23	1	6
Uruguay	17	11	19	4	7
US	17	11	22	4	5
Laggards					
Angola	4	4	15	0	1
Burundi	4	4	13	1	1
Kazakhstan	3	3	16	4	2
Kyrgyzstan	2	2	12	1	1
Lebanon	4	4	23	6	2
Monaco	0	0	0	0	0
Montenegro	3	3	21	5	2
Niger	3	3	10	0	2
Qatar	3	3	12	3	4
Romania	4	4	19	4	2
Russia	1	1	20	1	1
Swaziland	2	2	15	0	1
Syria	3	3	19	1	2
Togo	4	4	14	5	2

Leaders and laggards are defined by adaptation score and ordered alphabetically

constituting 43 % of the data set and highlighting the predominance of groundwork action among documented initiatives. All countries except Monaco report conducting at least one impact and vulnerability assessment, while 110 countries report the results of climate change scenarios. Adaptation research and conceptual tools are also being completed by 98 countries.

Among tangible actions, the largest reported number of initiatives falls into the category of infrastructure, technology, and innovation. Many of these initiatives involve the use of new seed varieties or irrigation techniques in the agriculture sector, and improvements to public infrastructure that address changes in water availability. Reviews of implemented adaptations are negligible, and there is limited reporting on organization development, public awareness and outreach, surveillance and monitoring, regulation, and resource transfers and financial support.

Notably, while the majority of groundwork initiatives are stand-alone initiatives, most adaptation actions are being implemented through mainstreaming into existing frameworks,

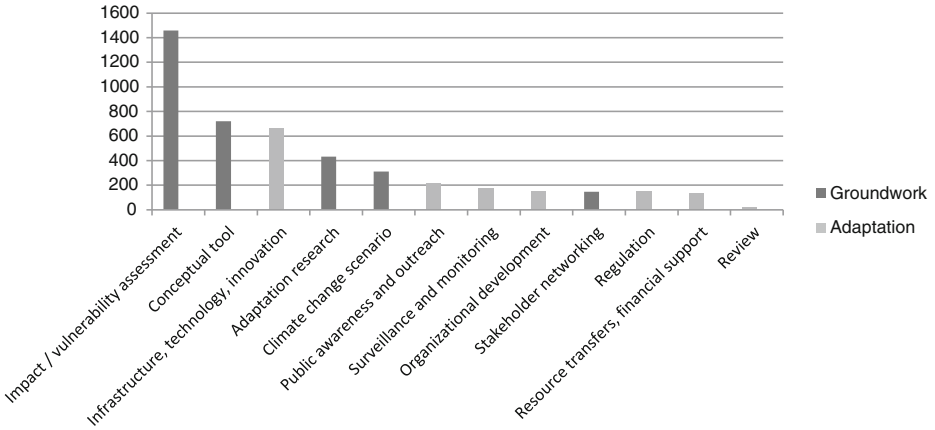

Fig. 1 Number of initiatives reported in each category of adaptive action

policies, institutions, and programs. Exceptions include organizational development, public awareness and outreach, and performance reviews. Organizational developments are frequently first-time initiatives, in the form of new departments, working groups, ministries, agencies. Public awareness and outreach activities were also in many cases autonomous initiatives. In total, 74 % of groundwork actions were autonomous initiatives, while 63 % of adaptation actions were mainstreamed.

3.3 Emphasis on vulnerabilities is consistent across levels of action

For most vulnerabilities, a majority of countries−more than half−are conducting groundwork activities. Groundwork was most frequently reported (>100 countries reporting initiatives) in response to drought, floods, food safety and security, infectious disease, rainfall, and water safety and security. These vulnerabilities are also the most frequently reported to be addressed at an adaptation level.

In contrast, implementation of tangible adaptations is limited. Only one vulnerability −water safety and security−is reported on by more than half of surveyed countries as having reached the level of adaptation action. Floods, food safety and security, and terrestrial ecosystem health are being addressed in adaptation initiatives by over 50 countries each, but none were reported in more than half of the countries included in this study. Notably, a number of vulnerabilities are reported at the adaptation level for fewer than 10 % of countries, including air quality, cold, desertification, displacement and conflict, frozen ground, mental health, runoff, traditional lifestyles, and wildfires (Fig. 2).

Vulnerabilities identified as Other are predominately those described too broadly in the communications to allow for more specific categorization. For example, 99 countries included reference to general threats of extreme weather events using a range of terminology: climate change vulnerability, extreme weather events, natural hazards, natural catastrophes, weather hazards, and extreme weather.

3.4 National governments and researchers dominate stakeholder involvement

The majority of initiatives reported in the national communications are occurring with contributions from national government (Fig. 3). With the exception of Monaco, all

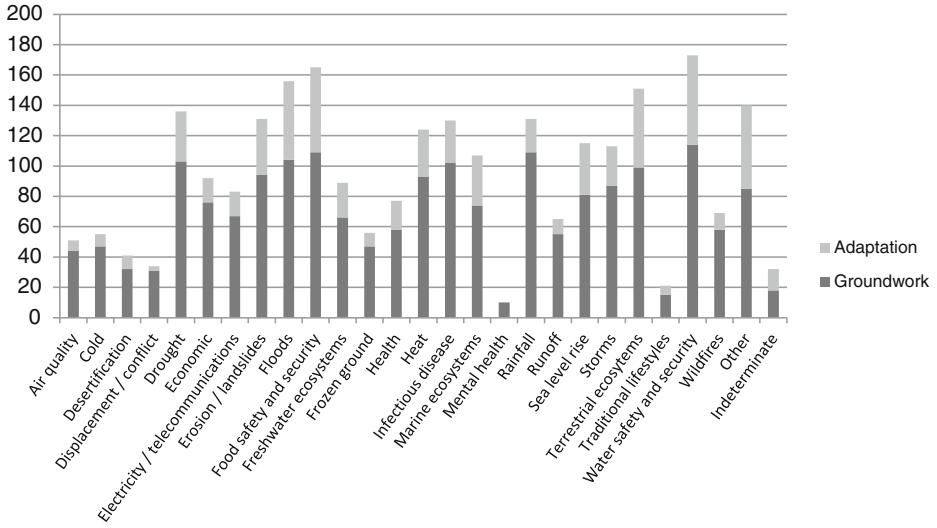

Fig. 2 Number of countries reporting adaptive action by category of vulnerability (Country counts exceed total number of countries (117) since groundwork and adaptation activities are counted independently)

countries reported groundwork action involving their national government. University and research communities are also contributing substantially to groundwork level activities, with 86 countries reporting initiatives involving university and/or research communities. Twenty-one percent of groundwork actions reported in the national communications are impact and vulnerability assessments conducted solely by university and research groups. Much of this is accounted for in the frequent citing of peer reviewed literature within the impact and vulnerability discussions in the communications.

National government involvement also dominates reported adaptation actions. Government contributions were more frequent among adaptation actions (85 %) than groundwork activities (59 %). In total, 33 % (1135/3396) of reported groundwork and adaptation actions

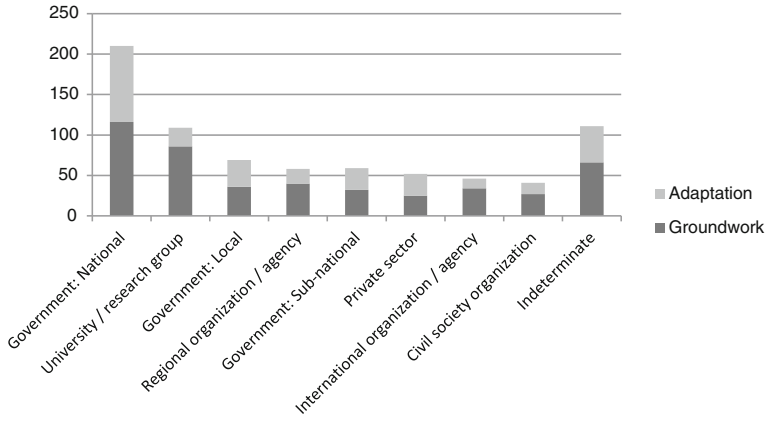

Fig. 3 Number of countries reporting stakeholder engagement at groundwork and adaptation levels. (Country counts exceed total number of countries (117) since groundwork and adaptation activities are counted independently)

involve no government participation (national, sub-national, or local). These findings reflect the fact that the national communications are compiled by national governments. It is likely that government-led initiatives are over-represented in most reports, as governments are more likely to report on what they consider to be representative of national strategies of adaptation, and on information that they are already aware of and have access to. Adaptation led by smaller local governments and civil society organizations may well be more extensive than what is found within the national communications.

Sectoral involvement in groundwork and adaptation mirrors trends in highly reported vulnerability categories (Fig. 4). The agriculture, environment, health, and water sectors emerge as the leading sectors in groundwork initiatives, with over 100 countries indicating groundwork actions taken in each of these sectors. On an adaptation level, however, only the agriculture, environment, and water sectors have over half of countries reporting action. Education, human services, and technology emerge as the least active sectors on both a groundwork and adaptation level. The national security and tourism sectors indicate the largest gap between groundwork and adaptation initiatives. While 67 countries indicate groundwork actions in the tourism sector, only nine indicate actions on an adaptation level. Similarly, 15 countries indicate groundwork actions in the national security sector, and only nine report actions on an adaptation level. National security is overall one of the least active sectors on climate change adaptation, as reported in the communications.

3.5 Vulnerable groups are poorly included in reporting of groundwork and adaptation responses

Reporting on the inclusion of vulnerable groups in groundwork and adaptation initiatives is low. More countries report including vulnerable groups in groundwork actions than adaptation actions, owing to the fact that two thirds of actions that consider at least one vulnerable group are impact and vulnerability assessments. Forty-seven countries report on the elderly at a groundwork level, while 39 and 38 report on children and groups in lower social position (particularly the poor and rurally isolated) respectively (Fig. 5). Reporting on vulnerable group inclusion in adaptation is lower. Only 14 countries report on inclusion of groups from lower social positions in adaptations, and only seven and five report on children and the elderly, respectively.

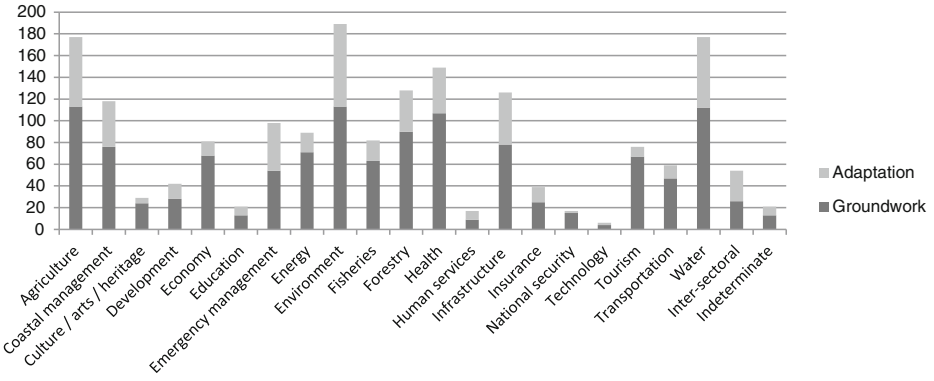

Fig. 4 Number of countries reporting adaptive responses by sector at the groundwork and adaptation levels. (Country counts exceed total number of countries (117) since groundwork and adaptation activities are counted independently)

Analysis of reporting on vulnerable groups indicates limited discussion across group category and across countries. No vulnerable group is being reported on by more than half of the countries included in this analysis. The highest reporting by countries is in regards to the elderly, with 50 countries including some discussion of vulnerability among elderly populations in their communication. However, it is noteworthy that in regards to consideration of the elderly in reporting on individual initiatives, only 1.5 % of all reported groundwork and adaptation actions included a discussion of the elderly. Similarly, 44 countries include a discussion of vulnerability among the poor or rurally isolated, but only 2 % of individual initiatives mentioned the inclusion of individuals from lower social positions in groundwork or adaptation actions. This trend continues across all categories of vulnerable groups. No category of vulnerable group is discussed in over 1.5 % of initiatives.

4 Discussion

The results of this study highlight a number of important trends. First, progress on adaptation at the national level is primarily occurring at the groundwork level. While virtually every country surveyed here reports conducting impact and vulnerability assessments and adaptation research—itself an important development—progress on actual adaptation interventions (including infrastructure projects, regulations, public outreach campaigns, and surveillance and monitoring) is limited. Adaptation is reported as a priority in certain sectors (e.g. environment, agriculture, water), while other climate-sensitive sectors including transportation and insurance are notably underreported. Mainstreaming remains the most common approach to implementing adaptation among the initiatives reported in the national communications, and while argued by some to be the most effective way to build capacity to manage the effects of climate change (Dovers 2009; Ford et al. 2010; Smit and Wandel 2006), others note that the magnitude of the risks posed by climate change requires transformative change and dedicated policy interventions (Adger and Barnett 2009; Kates et al. 2012). Attention to vulnerable groups is minimal across national communications, particularly in adaptation initiatives. The data suggest that consideration for vulnerable groups is also uneven across sectors; of the 163 initiatives reported to consider at least one vulnerable group, 100 involve the participation of the

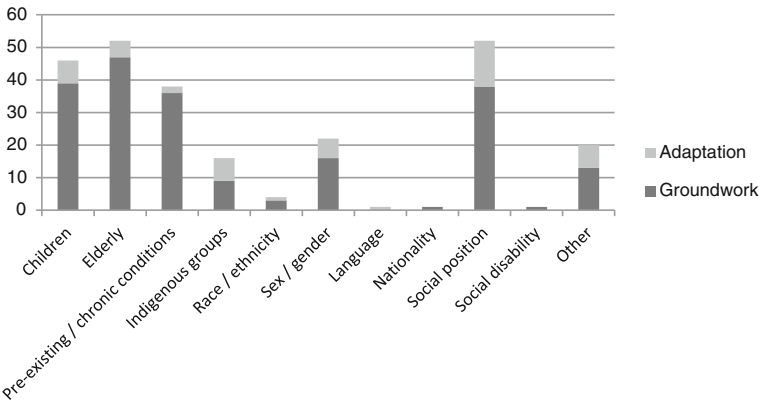

Fig. 5 Number of countries reporting on vulnerable groups at the groundwork and adaptation levels. (Country counts exceed total number of countries (117) since groundwork and adaptation activities are counted independently)

health sector. This trend is particularly notable given the disproportionate impact that climate change is projected to have on socially vulnerable groups (Paavola and Adger 2006).

This paper contributes both conceptually and empirically to a growing number of tools being created to summarize and compare vulnerability and adaptive capacity. With data from 117 countries from every region of the world, our findings provide a baseline understanding of global trends in adaptation. While indices like the climate change vulnerability index, global climate risk index, and the ND-GAIN index consider exposure, sensitivity, and adaptive capacity, they do not indicate how much is being done to respond to vulnerability through adaptation. Existing outcome indices, such as the environmental performance index, are not specific to climate change adaptation, and are thus unable to consider project-level action. To our knowledge the analysis presented here is the first systematic global comparison of adaptation initiatives using data from high, middle, and low income countries, and represents an important baseline development for tracking adaptation at a global level.

The methodology developed within this study tracks adaptation based on individual initiatives reported by national governments. The indicators used to code data are a hybrid of procedural indicators (e.g. inclusion of stakeholders, mainstreaming, sectoral involvement, identification of vulnerable groups, and actors) and implementation aspects of adaptation (e.g. types of actions being undertaken, and the character and implementation status of these actions). This hybrid set of indicators is used to compile a snapshot of adaptation across 117 countries. It is not expected that the information conveyed through the national communications presents an exhaustive description of the state of adaptation in each country. Rather it is assumed that the reports outline core progress considered by national governments to be representative of the nature of adaptation efforts in each county, with a focus on national-level initiatives. While adaptation efforts led by lower orders of government (e.g. state or local governments) are discussed in most national communications, the majority of the reporting focuses on adaptation activities that are occurring under the leadership of or in collaboration with national government. Adaptation efforts led by non-government actors (e.g. Poutiainen et al. 2013) are a smaller focus of the national communications, meaning that private adaptation efforts are likely underreported to the UNFCCC.

Growing recognition about the benefits of systematic tracking of adaptation (Eisenack et al. 2012; Berrang-Ford et al. 2011; Ford et al. 2011a, b, c, 2013; Tompkins et al. 2010; Hofmann et al. 2011) combined with recent progress on the prioritization of adaptation, provide an entry point for re-thinking how adaptation is reported on. The UNFCCC is in an excellent position to begin re-considering its role in collecting information on adaptation progress. The Cancun Adaptation Framework acknowledged "the need to strengthen, enhance, and better utilize existing institutional arrangements and expertise under the convention," and lays out a priority in "[s]trengthening data, information and knowledge systems, education and public awareness" (UNFCCC 2010). The recently created Adaptation Committee has been tasked with "[c]onsidering information communicated by Parties on their monitoring and review of adaptation actions, support provided and received, possible needs and gaps and other relevant information, including information communicated under the Convention, with a view to recommending what further action may be required, as appropriate" (UNFCCC 2010). While mitigation reporting already consists of well-developed methodologies for inventorying emissions across sectors and countries, tools to permit similar levels of tracking across adaptation are lacking. We propose that to better develop methods for tracking adaptation progress, emphasis is needed on identifying transparent, rigorous, and consistent guidelines and tools for reporting through the UNFCCC. With existing reporting obligations, consistent timelines, a global network of climate change experts, near universal participation, and a new focus on adaptation, the UNFCCC provides an institutional framework with potential to deepen and expand adaptation tracking efforts.

The development of a systematic approach for tracking adaptation outcomes across countries and use of national communications as our data source has a number of key strengths. The dataset creates a baseline for assessing progress over time, through which national adaptation progress can be monitored with respect to future communications which nations are required to submit at regular intervals. Furthermore, an adaptation action-oriented index such as the Adaptation Initiatives Index developed here, allows researchers and policy-makers to identify where progress on adaptation is being made, and where gaps in implementation are emerging. This methodology can thus contribute to decisions on critical next steps. A number of limitations to the approach are also evident, the most significant concerning differences in depth of reporting across countries and bias towards primarily national-level initiatives. This partly reflects the guidelines that form the basis of the chapters concerning vulnerability and adaptation, which are brief and non-specific, contributing to variations across reports in the level and quality of detail concerning research and interventions. Stronger guidelines and clearer expectations in reporting however would contribute to resolving uncertainty.

While current reporting methods conducted through the UNFCCC provide information about general trends in adaptation implementation, inconsistencies across national communications in quality of information prevent the creation of what could be considered an inventory of global adaptation. The format of the communications is currently insufficient to construct a more thorough record of global adaptation. Attention should be placed on developing tools for systematic adaptation tracking that can be applied by UNFCCC parties for better reporting progress on the implementation of adaptation requirements under the Convention.

First, there is a need to improve the guidelines set forward by the UNFCCC for reporting progress on treaty implementation. With adaptation policy and funding increasing in importance within the UNFCCC, critical reflection needs to happen around what constitutes progress towards meeting treaty obligations on adaptation, and what kind of information needs to be provided for tracking progress. Detailed procedural guidelines on how to report progress on adaptation would improve consistency between countries in the quality of information provided through the national communications, and make these documents more useful tools for assessing adaptation around the world. Robust reporting standards already exist for reporting on mitigation of greenhouse gas emissions; similar development needs to occur around reporting improvements in adaptive capacity and resilience. Second, reporting guidelines need to emphasize the importance of reporting project reviews on progress and / or effectiveness. This will empirically contribute to efforts to define and monitor "successful" adaptation, and encourage stakeholders to include measures of outputs and outcomes in intervention planning. Third, referencing standards need to be agreed on within discussions about adequate groundwork and adaptation measures.

Finally, we need to develop more appropriate tools for reporting information about adaptation progress. In helping policy-makers identify emerging gaps in adaptation progress, scarce resources could be better directed to where they will have the strongest impact. The UNFCCC also has in its mandate a responsibility to help developing countries at highest risk of climate change impacts with resources necessary to conduct impact and vulnerability assessments, adaptation interventions, National Adaptation Programmes of Action, and national communications. This mandate can be fulfilled more effectively and equitably if reporting guidelines and tools contribute to more transparent, consistent, and empirically-based adaptation tracking. While the format of the communications is appropriate for identifying overall trends, it is insufficient for conducting more detailed analysis.

One approach to support more systematic reporting from member countries is the creation of a central database on impacts, vulnerability, and adaptation to replace or compliment the

current chapter within the national communications. This database would go beyond existing inventories in its geographic spread and quantity of information; with 194 parties submitting information about adaptation interventions in one database, we would be able to more easily assess where adaptation is occurring (country or region), which stakeholders are engaging in adaptation, which vulnerable groups are being included in research and interventions, how adaptation is occurring (e.g. types of interventions, status of implementation), which vulnerabilities are being responded to, and whether interventions have been assessed in terms of effectiveness. Such a database would have application beyond fulfilling the reporting requirements of the Convention. In creating a more robust global inventory of adaptation, it would aid in assessing whether funding for adaptation is being distributed to those regions and groups who are at highest risk.

An effort must also be made to develop mechanisms for tracking progress on private adaptation, which can complement UNFCCC reporting mechanisms for governments. Identifying adaptation efforts led by civil society organizations and individuals is critical to capturing a complete picture of the status of adaptation across countries. Poutiainen et al. (2013) have examined adaptation to health impacts of climate change among civil society organizations in Canada. Further work could consider how this approach could be integrated into adaptation tracking efforts led by the UNFCCC.

Re-thinking the role and potential uses of adaptation reporting with the UNFCCC is not without challenges, one of the greatest of which is differences between national government capacities to collect data and information and reach out to stakeholders across scales and sectors. Much clearer expectations for the level and quality of information, however, would contribute to reducing these inequalities, especially among countries reporting in a language other than the national language(s). Determining appropriate means of systematically measuring the impact of adaptation interventions will be the next step in expanding this methodological approach, one that may have a critical impact on deepening our knowledge about adaptation processes, opportunities, barriers, and challenges, and the sharing of good practices.

With an increasing focus on adaptation within the international climate change regime and expansion in financing for adaptation interventions, the need for robust and transparent methods of tracking progress on adaptation is growing. The results of this paper demonstrate that while enough information is available through the reporting mechanisms of the UNFCCC to identify global trends about adaptation responses, steps must be taken to develop tools and directives that will guide a more systematic collection of information. The UNFCCC institutions provide a foundation on which we can build a global adaptation tracking system. What remains is to take advantage of this opportunity to build an innovative system for global adaptation monitoring that will provide a wealth of empirical information for policy-makers, researchers, and community leaders.

5 Conclusion

This study makes an important contribution to the growing need for tools that measure progress being made on adaptation. Focusing on adaptations reported by national governments through the national communications to the UNFCCC, we provide a snapshot of adaptation occurring across regions and high, medium, and low-income countries.

Our findings demonstrate that adaptation efforts at a national level are primarily occurring with groundwork actions like impact and vulnerability assessments, adaptation research, and the development of conceptual tools to guide adaptation. Tangible adaptations are occurring most frequently in regards to infrastructure, technology, and innovation. Key vulnerabilities

emerge across countries as concerns, including food and water safety and security, flooding, drought, changing rainfall patterns, and infectious disease. Progress on addressing these vulnerabilities is primarily demonstrated at the groundwork level. Adaptation progress is unevenly reported across stakeholder groups, suggesting that the national communications are not capturing adaptation being led at a local level or from within civil society. Uneven reporting on adaptation across sectors suggests that some sectors, for example agriculture, environment, health, infrastructure, forestry, coastal management, and water, are more proactive on adaptation planning and implementation at the national level.

With adaptation increasing in prominence within the UNFCCC framework, there is an opportunity to engage in a discussion about how the national communications can be better used to track the state of adaptation around the world. Improvements in the reporting guidelines and development of new tools for submitting information would strengthen the clarity and depth of information provided, and make the national communications a robust mechanism for tracking progress on adaptation.

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