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Informatics Capacity to Manage Local Climate Change (LCC) Effects

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Abstract

The capacity to manage local climate change (LCC) effects will depend upon the stakeholders' capacity to manage the data, information, interpretation, and knowledge (semiotics) about it. The stakeholders include governments, researchers, businesses, educators, non-government organizations (NGOs), and the people affected by and affecting the LCC. The public managers must build this semiotics management capacity among the stakeholders to minimize a locality's vulnerability to LCC, and to handle the associated uncertainty and ambiguity. It is a complex, ill-structured task.

The locality must be resilient in the face of LCC – it will have to resist, respond to, recover from, restore, and be renascent to the effects. The LCC effects themselves may be a combination of agricultural, coastal, ecological, hydrological, human health, land use, and meteorological effects.

The capacity to manage the semiotics of LCC effects will depend upon the infrastructure, organizations, systems, policies, and procedures (informatics structure) to acquire, store, retrieve, process, distribute, and delete (informatics functions) for the four elements of semiotics. The above logic is encapsulated in the ontological framework below.

The first three columns represent the structure, functions, and semiotics dimensions of informatics. The next two columns represent the stakeholders and resilience dimensions of management. The last column represents the LLC effects. The concatenation of an element from each column with the connectors in between is a natural English statement of a component of the problem. There are 99,000 possible components – some of them may be meaningless or irrelevant.

The framework articulates the combinatorial complexity of the public managers' problem and the large number of components they must address to build the necessary capacity.

The paper will present a systematic review of the global scientific literature on LCC effects management. It will highlight the frequently emphasized, infrequently emphasized, and ignored areas in policy research on the topic. It will analyze the potential reasons for and the consequences of the different emphases. It will conclude with a roadmap for future research. The framework will also help coordinate the multi-level governance necessary to manage LCC effects.

Keywords: Entrepreneurship; Agricultural; Marketing Behaviour

Abbreviations: NGO: Non-Government Organizations; ICT: Information and Communication Technology; UNFCCC: United Nations Framework Convention on Climate Change; COP: Conference of Parties; WOS: Web of Science; IPCC: Intergovernmental Panel on Climate Change; IMD: Indian Meteorological Department

Introduction

Managing local climate change effects has become a global problem. The capacity to manage these effects will depend upon the stakeholders' capacity to manage the data, information, interpretation, and knowledge (semiotics) about it. These stakeholders include governments, researchers, businesses, educators, non-government organizations (NGOs), and the people affected by and affecting the LCC. The public managers must build this semiotics management capacity among the stakeholders to minimize regions vulnerability to LCC and to handle the associated uncertainty and ambiguity. It is a complex, ill-structured challenge. It requires multi-level governance.

The public managers are required to make the locality resilient to LCC – to resist, respond to, recover from, restore, and be renascent. The LCC effects themselves may be a combination of anthropic (agriculture, livestock, fisheries, land use, health, and other) and natural (coastal, hydrological, meteorological, ecosystem, other) effects.

The capacity to manage the semiotics of LCC effects will depend upon the infrastructure, organizations, systems, policies, and procedures (informatics structure) to acquire, store, retrieve, process, distribute, and delete (informatics functions) the data, information, interpretation, and knowledge. The above argument can be encapsulated in an ontological framework. The framework articulates the combinatorial complexity of the public managers' problem and a large number of components they must address to build the necessary capacity.

The paper will map and present a systematic review of the global scientific literature on LCC effects management and highlight its 'bright', 'light', 'blind/blank' elements [1-3]. It will highlight the frequently emphasized, infrequently emphasized, and ignored areas in policy research on the topic. It will analyze the potential reasons for and the consequences of the different/partial emphases. It will conclude with a roadmap for future research by generating research questions based on the differentiated emphases. The framework will also help coordinate the multi-level governance necessary to manage LCC effects.

Ontological Framework

An ontological framework of informatics capacity to manage local climate change effects is shown in Figure 1. The first three columns of the framework represent the structure, functions, and semiotics of informatics. The next two columns represent the stakeholders and resilience of management. The last column represents the LCC effects. The concatenation of an element from each column with the connectors in-between is a pathway to manage the effects of LCC in natural English. There are 99,000 possible pathways, some of which may be meaningless or irrelevant. Three are listed below, with an example of each.

- Infrastructure to acquire data by governments (federal/central) for local resistance to agricultural effects. Example: Hardware, software, networks, people ware to collect current data from farmers.
- Procedure to distribute knowledge by educators (university) for local renascence from land use effects. Example: Procedures to distribute research findings of reversing adverse land use effects.
- Systems to retrieve information from researchers (university) for local response to human health effects. Example: A Curated archival system of historical human health information about a local community.

The framework articulates the systemic complexity of the public managers' problem and the large number of issues they must address to build the necessary capacity.

Corpus of Policy Research on Informatics of LCC

We searched the Scopus and Web of Science (WoS) databases for all articles using the following search string:

"climate change" AND ("information system" OR "information systems" OR

"information technology" OR "information technologies") AND local.

WoS retrieved 216 articles and Scopus 421. From these articles, only those published in journals and with abstracts were selected. The selection resulted in 482 articles. After eliminating 129 duplicates, the final corpus contained 353 articles. They were coded onto the ontological framework.

The timeline of the articles range from as early as 1995 till 2017. The articles focused on a variety of countries - Western Burkina Faso, Ebony in South Eastern Nigeria, Benin-Ghana, New York state, Columbia (Maryland), Papua New Guinea (Solomon Islands), Southern France, Drome river in France, Emilia Romagna from North East Italy, Munich -Germany, Norway, Caribbean Islands, California (USA), Husteca Potosena in Mexico, Pakistan, Gujarat in India, Himalayas in India, Doha in Qatar, China, Hanoi province in Vietnam, Ecuador from South America, Ciguatera -Queensland-Australia, and others.

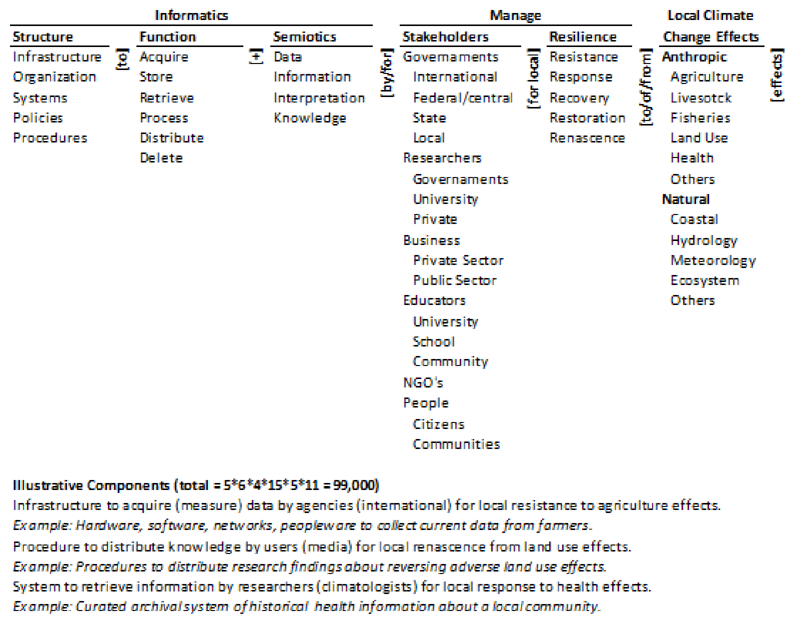

Figure 1: Ontological Framework of Informatics Capacity to Manage Local Climate Change Effects.

Coding of the Corpus

Three of the authors mapped 353 abstracts onto the ontological framework using an Excel-based tool in two cycles. In the first, training cycle, all three coded 50 articles based on their abstract, title, and keywords. In the second cycle, each person coded two-thirds of the remaining articles, ensuring that at least two people coded each abstract. The distribution of the articles ensured that each person's sample overlapped equally with the other two. A few articles were eliminated during coding as not being relevant.

Each cycle has two iterations. In the first iteration, the authors coded the articles individually. Based on their coding, a comparison matrix was generated to highlight the similarities and differences in their coding. In the first cycle, the comparison matrix was based on three coders. In the second cycle, it was based on two coders. In the second iteration of each cycle, the coders (three or two, depending on the cycle) reconciled the differences and recoded the articles. The reconciliation was based on discussion of the abstracts, titles, keywords, glossary, and framework.

The coding was individual. It was also binary-whether the ontological element was present in the abstract or not. The frequency of the occurrence of an element in the abstract was not counted. The glossary was used to assure the validity of coding. The consensus coding assured the reliability of coding.

Results

The results of mapping of the corpus onto the ontological framework are shown in Figure 2. The numbers in parentheses adjacent to each dimension and element show the number of articles in the corpus that refer to that dimension/element. Of the 353 articles coded 331 refer to the Structure, 330 to the Function, and 334 to the Semiotics of Informatics; 202 refer to Stakeholders and 262 to Resilience in Management, and 337 refer to LCC Effects. Relatively, there is less emphasis on Management compared to Informatics and LCC Effects in the corpus.

In the Informatics Structure, the 'bright' (most frequently emphasized) elements are Infrastructure and Systems. Organizations, Policies, and Procedures are 'light' (less frequently emphasized) elements. There are no 'blind/blank' (ignored) elements.

In the Informatics Function, the 'bright' elements are Acquire, Store, and Process. The 'light' elements are: Retrieve, Distribute, and Delete. There is no 'blind/blank' elements, although Delete is close to being so.

In the Informatics Semiotics, the 'bright' elements are Data and Information. The 'light' elements are Interpretation and Knowledge. There is no 'blind/blank' element.

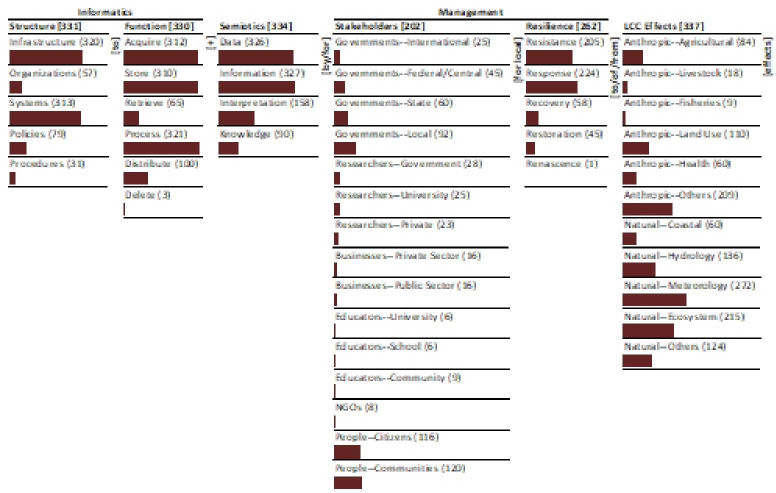

Figure 2: 'Bright', 'Light', and 'Blind/Blank' Spots of Informatics Capacity to Manage Local Climate Change Effects.

Among the Stakeholders, given that only 202 of the 353 articles consider stakeholders, the 'bright' elements, and they are: People-Citizens, and People-Communities. The emphasis on the rest of the Stakeholder elements is 'light'. That includes the different levels of Governments, types of Researchers, types of Businesses, Educators, and NGOs. There are no 'blind/blank' elements, although Businesses, Educators, and NGOs are close to being so.

Among the elements of Resilience, the 'bright' ones are Resistance and Response; the 'light' ones are Recovery, Restoration, and Renascence. Renascence is virtually a 'blind/blank' element.

Among the LCC effects, the 'bright' ones are Natural effects on Meteorology and Ecosystem and Anthropic – Other effects. All the other effects are 'light'. There is no 'blind/blank' effect, although Anthropic-Fisheries is close to being so.

Taken together- the dominant focus of the corpus can be said to be on:

Infrastructure/systems to acquire/store/process data/information by/for people (citizens/communities) for local resistance/response to natural (meteorological/ecosystem) and miscellaneous anthropic effects.

The corpus' does not appear to emphasize:

- Organizations, policies, and procedures – institutional aspects of informatics.
- Retrieval, distribution, and deletion in informatics.
- Interpretation and knowledge generation and application.
- Non-people stakeholders.
- Recovery, restoration, and renascence.
- Specific anthropic effects and natural-coastal and other effects.

Discussion

Multiple elements of a dimension may coexist independently but may also interact with each other. Thus, many stakeholders, resilience stages, and climate effects may coexist and interact with each other. Knowing the independent and interacting elements is critical to understanding informatics capacity to manage local climate change. The framework can help systematically study and manage the elements' interrelations and interactions. Further, we discuss how the ontology can be used to systematically study the interaction of (a) elements within a dimension, (b) elements across two dimensions, and (c) elements across multiple dimensions, to understand the anatomy of effects of local climate change at different levels of granularity and complexity. A robust climate information system is imperative for informing climate policy at the local, state, federal and international levels.

Structure

The results of ontological mapping reveals a strong focus on the Infrastructure and Systems elements of the Structure dimension. Infrastructures are an asset that facilitate adaptation. Infrastructure and the Systems of informatics are employed only to Acquire/Store/Process the Data and Information, but not to Retrieve and distribute the information. Utilization of Geographical Information Systems to combine ecological, socio-economic, territorial and other aspects in order to facilitate planning and developmental strategies [4], feature strongly in our results. However, while the necessary infrastructure may drive or facilitate an effective response to local climate change effects, lack of organizations, policies and procedures make the information system incomplete.

Infrastructure (320) and Systems (313) bright spots were coded together in 207 records out of 304 revealing their joint importance in the present and past policy-making sphere. Organization (57), Policies (79) and Procedure (31) as a light spot reveals Policy and Procedures are essential for organizations to take an effective planned course of action for resilience. Urban Climate Map System for Dutch spatial planning proved that policy and procedure working together could lead to a successful implementation of any local climate change System [5].

According to IPCC, federal governments play a key role in adaptation planning, and implementation. A limited understanding of the necessary Organizations, Policies, and Procedures may be a barrier or inhibitor to an effective response. Examples drawn from climate impacts related to hurricanes, El Nino events and glacial retreat in America are presented in the paper [6] which suggests "[c] communication across multiple disciplinary perspectives is necessary to ensure that decision-makers can understand indicators and develop appropriate responses". Improved cross-disciplinary communication is needed to promote the effective decision making for LCC resilience.

Function

The capacity to manage climate change effects will depend upon the stakeholders' capacity to manage the evidence about it. Thus the value of evidence – Data, Information, Interpretation, and Knowledge – as an asset lies only in functions of the underlying informatics. In the past few decades Information and Communication Technology (ICT) has profoundly altered societies around the world, with people and information becoming ever more connected. The trends in access to and consumption of Data and Information have been constantly evolving. The basic functions (Acquire, Store, Retrieve, Process, Distribute and Delete) have now expanded into generate, capture, measure, update, index, encrypt, locate, assess, integrate, transmit, deliver, deduplicate etc. A deep understanding of all the Functions can drive and facilitate an effective response to LCC.

The value Processing holds in Information system is very huge. For example, only a GIS system can analyze greenhouse gas mitigation policy to set up carbon sinks at district level [7]. Similarly, Spatial analysis of Land Use can be used to monitor land use change and forestry to support decision making for enhancing carbon sequestration [8]. Data Retrieval and Data Distribution are usually used together since data retrieval is quintessential for data distribution. They could be used to gather feedback and improve the current system or to be spread as a base for various other overlapping studies or for integrating multiple small systems to a larger system [9]. Different information systems of meteorological, climatological, geo-physical, hydrological and agricultural was used to construct crop calendar information system which in turn disseminated cropping and seasonal information to the farmers [10], hence a limited understanding of retrieval and distribution may inhibit an effective response [11].

Delete function of data semiotics in an Information system with excessive uncertainty regarding quality, long periods of erraticism and futile are required to check redundancy and duplication and make way for better Data semiotics. Greater the size of Data, Information etc., more arduous is their management. Time to time data deletion is thus quite necessary. Ignorance of the role of deletion may significantly diminish the effectiveness of the response to LCC effects [12].

Semiotics

The semiotic cycle from Data to Knowledge and from Knowledge to Data is essential to any effective informatics. The results depict a heavy emphasis on Data and Information. However, the Interpretation and Knowledge elements are less emphasized. During generation, data is converted to knowledge and during application knowledge is converted to data [13]. This bi-directional semiotic process is essential for effective informatics to manage LCC effects.

Facing climate change and global warming, the outdoor climatic environment is an important consideration factor for planners and policymakers. Improving it can greatly contribute to achieve citizen's thermal comfort and create a better urban living quality for adaptation. Thus, the climatic information must be assessed systematically and applied strategically into the planning process.

Data and Information are the foundation for resilience strategies in addressing climate change. Absence of any one of these may lead to 'Data poverty' or 'Information poverty' used in the context of a lack of effective and reliable data and information for hazard assessment and decision-making in low-income countries, which has direct implications on a country's economy, Policy, Development and foreign relations [14]. In the Indian context, most information on environment and climate is collected by the government and the Indian Meteorological Department (IMD) [15]. This collected data is ridden with problems of falsification and improper management of records (ibid). The information system becomes even more redundant if there are no means to interpret such data and produce valuable knowledge for making climate change policy decisions. In order to achieve resilience to climate change in societies a transdisciplinary perspective through knowledge systems, that are inclusive of citizen interpretation and understanding is of prime importance.

Despite the drawbacks of interpretation they are necessary assumptions made based on scientific evidence to enhance knowledge further. Bridging the gap between the predictions of coarse-scale climate models and the fine-scale climatic reality of species is increasingly recognized as a key issue of climate change biology research [16]. Such researches can be complete only with inferences and interpretations backed by evidence to be further used to create knowledge. Less emphasis on interpretation and even less on knowledge may diminish the meaningfulness and pragmatism of the response to LCC effects.

Stakeholders

Systematized climatic information that is locally driven through stakeholder participation and government intervention can provide a strong grounding for adaptation and mitigation strategies. The information systems on climatic variables can be extrapolated from the local level and used as a response to global climatic events. Our coding results show limited focus on stakeholder participation and integration, with only slightly higher focus on local communities and citizens. A reason for increased community participation could be the incorporation of Participatory GIS (PGIS) methods which help in mapping the knowledge of local people on the various impacts of climate change situations that they are experiencing [17]. This kind of infrastructure has led to the democratization of the conventional GIS set up, by providing for the multiple ground realities that exist in a local community level. By involving people participation and capacity building, providing insightful solutions to the climate change conundrum becomes a less elusive task. A sound climate information system is reinforced with the addition of community inputs and active citizen involvement. Appropriate policy implementation requires the existence of a policy subsystem, that essentially consists of several diverse, autonomous stakeholders who strive to influence policy decisions [18]. The successful implementation of a watershed management system in the Drome area in France was attributed to the high quality of partnerships among various stakeholders as well as social perspectives on the issues of water governance [19].

A study by Schoenefeld, et al. [15] reveals that the responsiveness to climate change depends on the orientation of local values and beliefs of the people and not just on the level of information provided. Furthermore, the bureaucratic management of information results in an exclusionary culture thereby restricting diverse and interactive participation among stakeholders. Politicization of various climate issues can lead to biased outlooks which may take precedence over scientifically validated knowledge. To combat this, involvement with all stakeholders at various levels is required.

Researchers at the government, university and private level, feature as light spots in our ontological analysis. Local knowledge is gaining increasing relevance in confronting the global problem of climate change. To contextualize this problem and magnify it to a more detailed proportion, involvement of researchers at such a level can serve meaningfully. Researchers can further enrich the information system with relevant real time inputs. The interaction between central and state authorities along with NGOs and university researchers has allowed for the establishment of a climate information system that aims at informating climate and agricultural policy in New York [20].

Government participation at all levels is lacking, which has further contributed to the exacerbation of the climate change problem. Planning, transportation, infrastructure and land use decisions taken by local authorities inevitably affect climatic outcomes [21]. Therefore, it becomes essential to integrate governments and government bodies with a well-established climate information structure. The information infrastructure that draws from government departments can allow for a comprehensive database which can form the foundation for resilience and resistance planning. Quebec's open source application for prevention of health impacts due to meteorological events, allows for the interaction of government departments, federal organizations in charge of weather and environment and research partners, to establish a surveillance and prevention system in response to health impacts due to meteorological changes. Cooperation with governments and various stakeholders has aided in the success of this system [9]. Stakeholder engagement is the basis of an ideal information system for local climate change which is interdisciplinary and combines scientific and indigenous knowledge to propel rational adaptation decisions.

Resilience

The choices and processes of ensuring that the world can deal with climate change effects and climate change drivers are usually termed 'building resilience'. The ability of stakeholders to 'resist to' 'recover from' 'adjust and adapt to' whether in an 'ex-ante' or 'ex-post' manner, and that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change effects is called as resilience. A comprehensive resilience strategy involves the phases of recovery, restoration and renascence. The general idea of resilience according to the people and communities in the study is to respond and resist to climate change effects. The idea of recovery and restore gained tertiary importance, and these resilience elements are prominent in only ecosystem studies [22], for instance, study of amphibians, Coral reefs, forests [23], birds and animal conservation studies [24]. The results of ontological mapping reveal a strong focus on Resistance and Response with minimal focus on Recovery, Restoration and Renascence. The cycle of steps from resistance to renascence is the continuous process of resilience [13]. An ontological examination of the corpus reveals that while several projects have utilized GIS models [17,25-27] to assess the vulnerability of communities to various climatic adversities [28], clear roadmaps to prevent or reduce such impacts in the future are only lightly emphasized. With climate change issues gaining greater traction, wider agendas of disaster risk management and sustainability can be achieved. This requires looking into the root causes of resilience and vulnerability in order to inform broader policies of climate change and sustainable development [29]. Only the governmental organizations have contributed to response and resistance to climate change effects. Though increasing resilience is an overarching objective of the people to cope with climate change effects, the governmental organization are propelling on the ex-post reactive mechanisms to LCC effects in the system.

LCC Effects

Natural effects are important but ultimately the Anthropic effects of LCC need to be managed. The limited and unrefined focus on Anthropic effects can seriously limit the capacity to manage them. Among the natural effects, the limited focus on coastal effects may limit the ability to manage some of the most visible effects of LCC. Results have identified four important climate change effects i.e., water sources and systems i.e., Hydrological [30], climatic variables (Meteorological), plants [10], animals, forests, mountains (Ecosystem) and on livelihoods of people i.e., socio-economic well-being of people [20]. The infrastructures of information systems are employed for acquisition and storage of data and information for resistance and reacting to hydrological, meteorological, socio-economic and ecosystem effects of climate change. The stakeholders are not the dominant focus according to the present study, whereas studies by Comby, et al. [19] prove that, stakeholders [31] involvement has significantly improved the integrated management of river water systems in France, it even helps to reach a common agreement to address the problem. The agricultural effects, human health and Coastal effects has gained tertiary importance, whereas LCC effects on natural systems has gained highest emphases.

Anthropic – Other includes other anthropic factors such as economic, social, political, demographical, cultural, developmental etc. This goes on to Indicate that research and policies focus more on the secondary and tertiary effects of all stakeholders rather than the Primary factors such as agriculture and health [32]. Since the dominant focus is on resisting LCC effects in natural systems, the inclusion and involvement of formal organizations, people and infrastructure is lacking, thereby affecting the incremental responsiveness of people to anthropic LCC effects. Ignorance of the role of deletion may significantly diminish the effectiveness of the response to LCC effects.

Conclusion

The uneven emphases and skewed focus of climate change studies entirely on the impacts has neglected the importance of information acquisition, retrieval and distribution to the various stakeholders. Climate change is a complex, ill-structured challenge with multiple effects. The preconditions to manage climate change effects will depend upon the stakeholders' capacity to administer climate information systems. To minimize a locality's vulnerability to LCC the public managers must make the locality resilient to LCC. The above arguments encapsulated in an ontological framework, which deconstructs the complexity of climate change effects and provides a large number of components, public managers need to build the resilience. There is an incongruity and lack of mutual trust between science and society. The non-involvement of some stakeholders to manage climate change effects could negatively impact resilience. It may adversely affect the ability to reach a common agreement on regional climate change response mechanisms. The bi-directional semiotic process has not received significance. Neither is there any formal organizations for building conditions to resist and respond to adverse climate change effects. The dominant focus is not on stakeholders, interpretation of knowledge, its distribution and further documentation. The livelihoods of people, as well as primary sectors of the economy has received tertiary emphases. Organizations of informatics to recover, restore are of quaternary importance to manage LCC effects on livestock, fisheries and Coastal regions. The role of international governments, treaties, protocols and conference of parties (CoP) to mitigate the impacts of climate change have been given little emphases. Despite ratifications and agreements by United Nations Framework Convention on Climate Change (UNFCCC) and CoP at the international level, their coverage is limited in the present research.

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