Managing Disasters in a Compounding Scenario: A Case of Adaptive Governance in the State of Odisha, India

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Abstract: The study presents the success story of adaptive governance in managing compounding disasters. Adaptive governance helps address the challenges of compounding disasters through its approach, which entails flexibility, collaboration, and continuous learning. Odisha, one of the disaster hotspots states in India, has faced the wrath of many disasters, but the devastation caused by Super Cyclone 1999, which killed around 10,000 people, has been the most severe. Since then, the Government of Odisha has set an example to other states and countries to emulate its disaster management model. This article explores the success case of the Government of Odisha in dealing with compounding disasters through its adaptive governance model. The method consists of a desk review of its disaster management policies for the state and on-field discussions with a wide array of stakeholders ranging from government officials, international nongovernmental organizations (INGOs), nongovernmental organizations (NGOs), people representatives and communities for understanding measures, processes followed, and governance and its disaster model. The implications of this research will help other developing countries learn and replicate Odisha's success story in dealing with compounding disasters.

Keywords: *Compounding Disasters, Adaptive Governance, Odisha, India*

Introduction

The term "compounding disasters," also termed as "cascading impacts," "compound events," or "compound climate risks," are defined as situations where a solitary hazardous incident occurs, leading to significant consequences for both people's lives and their means of living. Moreover, this initial event triggers subsequent secondary or tertiary occurrences. A prominent historical instance illustrating this is the 1906 San Francisco earthquake. Although the earthquake was considerable in magnitude and caused significant damage (over 3,000 brick buildings were lost), the most devastating impacts resulted from the ruptured gas lines and the subsequent fires. These fires spread across the city, exacerbating the destruction and loss of life caused by the initial seismic activity (Cutter 2018).

The idea of compound/cascading disasters has become more relevant due to their capacity to cause humanitarian crises and disrupt economies. The rise in interconnected large disasters and the realization that extreme events do not always have extreme consequences have contributed to this increased interest (Cutter 2018). There is a significant lack of research and understanding regarding how a single event, like an earthquake followed by a tsunami, can lead to subsequent disasters, as seen in the case of the Fukushima nuclear power plant

disaster in Japan. The social impacts of such cascading events, not only within the affected nation but also globally, remain insufficiently explored and studied (Cutter 2018).

"Compounding disaster" is also termed "catastrophic disaster," as these disasters are extensive and prolonged, with compounding effects. COVID-19, extreme weather, and slow-onset events pose a huge challenge for governments worldwide to deal with compounding disaster effects. Extreme weather events, coupled with the pandemic, pose considerable challenges for the government to maintain physical distancing norms during evacuations and response actions. The impact of compounding disasters has affected lives and livelihoods and does put a question mark on resilience to future shocks. These challenges have affected developing and developed countries worldwide. For instance, in 2021, Kenya witnessed a pandemic, combined with floods and locust infestation, which aggravated the food insecurity position of the country. The same is true with Honduras, where subsequent hurricanes during the pandemic have posed several survival questions for many marginalized and poor sections of the society. The compounding disasters have also not spared the developed countries, as reported by the Emergency Events Database (EM-DAT, a data repository that compiles data on technological and natural disasters worldwide). It indicates that the deaths from disasters (up to August 2021) were highest in Europe and Central Asia. In developed nations, such as the US and Canada, heat wave and the rising cases of COVID-19 together have affected and resulted in the deaths of many people.

Adaptive governance can be understood as a spectrum of engagements involving individuals, networks, groups, and establishments that develop while striving for a preferred condition within social and ecological frameworks. The idea of disaster governance has been a topic of conversation within the domain of disaster risk reduction for the past ten years. It underscores the interconnected array of principles and entities at the organizational and institutional levels, and actions (encompassing periods before and after disasters) formulated to mitigate the consequences and damages linked to disasters (Chaffin, Gosnell, and Cosens 2014). Only in the past five years has the concept been thoroughly examined in the context of mitigating disaster risks and enhancing resilience to climate change (Djalante 2012). Djalante, Holley, and Thomalla (2011) outlined four essential attributes of adaptive governance crucial for fostering disaster resilience. These attributes encompass (1) decentralized and multitiered institutions, (2) involvement and cooperation, (3) self-organization and networks, and (4) learning and innovation. The definitional aspects of the concepts are explained in Table 1.

Table 1: Definitional Concepts

Terminology	*Definition*	*Reference*
Cascading Impacts	Cascading impacts stemming from severe weather or climate events arise when an initial extreme hazard sets off a chain of subsequent events within both natural and human systems. These events lead to disruptions across physical, natural, social, and economic domains, resulting in consequences far more extensive than the original hazard. Cascading impacts are intricate and varied, influenced largely by the vulnerability of the systems involved rather than solely by the intensity of the initial hazard.	Intergovernmental Panel on Climate Change (IPCC) (2022) and Pescaroli and Alexander (2015, 2018)

Terminology	*Definition*	*Reference*
Compound Events	The terms "compound events," "compound extremes," and "compound extreme events" are used interchangeably in climate change literature. They describe situations where multiple factors or hazards come together, contributing to risks for society and the environment.	IPCC (2021) and Zscheischler et al. (2018)
Compound Climate Risks	Arise from the interaction of climate change risks, which may be characterized by single extreme events or multiple coincident or sequential events that interact with exposed systems or sectors.	Simpson et al. (2021)
Adaptive Governance	The adaptive governance framework depends on the cooperation of a varied group of participants functioning at various social and ecological levels within multiple institutions and groups.	Olsson, Folke, and Berkes (2004)

From the review of literature, the conditions that led to adaptive forms of governance (Walch 2019) in Odisha have been observed, but the research question is how the state of Odisha has equipped itself and evolved as a role model in the field of disaster management to face the challenges of compounding disasters. What are key elements of adaptive governance that are visible in the state's policy and, most importantly, implemented on the ground? Another key research question is whether the Odisha model of disaster management can be replicable and scalable in other countries facing the same problems.

The broad objective of this article is to understand how the government in developing countries (here we present the case of the state of Odisha in India), despite resource and other technical constraints, has transformed itself as a model state in disaster management in India following the principles of adaptive governance. The present research sheds light on the adaptive governance aspects of the Government of Odisha in dealing with compounding disasters and how this model of disaster management can be replicated in other developing or underdeveloped countries.

The remainder of the article is organized as follows: Case Selection and Method presents the case selection and method adopted, Compounding Disasters Leading to Adaptive Governance theorizes the links between compounding disasters and adaptive governance, Disaster Management—Institutional Structure discusses the institutional arrangements in the disaster management sector in Odisha and highlights the role of different institutions, Discussion and Analysis argues how the key elements of adaptive governance were implemented in relation to compounding disasters, and Conclusion ends by critically analyzing the different strategies of the Government of Odisha to be a disaster-resilient state.

Case Selection and Method

Brief Profile of Odisha

Odisha is endowed with vast mineral and marine resources. It transformed from an agrarian economy to an industry and service-sector-led economy (Directorate of Economics and Statistics [DES], n.d.). Although the National Institution for Transforming India (NITI), Government of India, reflects that around 15.68 percent of the state population is

multidimensionally poor (NITI 2023), the state has performed well in many of the development indicators. The multidimensionally poor population is affected by changing climate dynamics due to their dependence on climate-sensitive sectors. Further, the sub-tropical coastal location of the state makes it fragile as it is home to the most extreme weather events arising in the Bay of Bengal. Cyclones from the Bay of Bengal cause severe destruction, bringing storm surges and heavy rainfall, which triggers riverine flooding (Ray-Bennett 2016). Figure 1 shows a map of Odisha and the shaded districts are the study areas—the Kendrapara and Ganjam districts of Odisha in India.

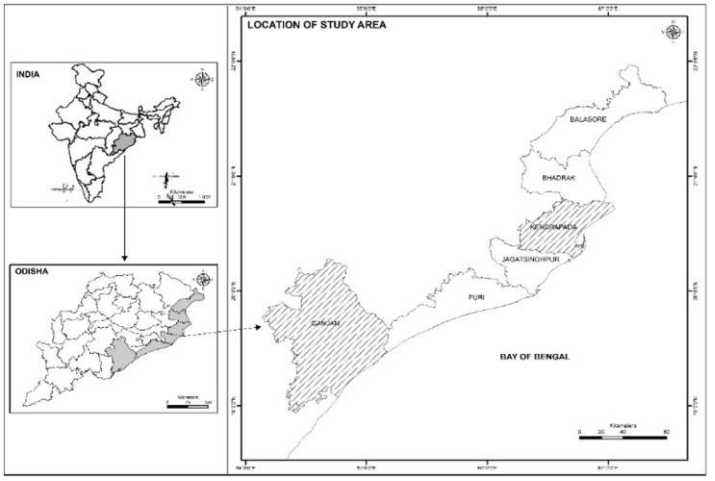

Figure 1: Study Area

The state of Odisha faced the effects of a pandemic and a cyclone at the same time. Cyclone YASS hit the state in 2021 at a time when the state was dealing with a spike in COVID-19 cases (Special Relief Commissioner [SRC], n.d.-c). The state faced the enormous challenge of evacuation of vulnerable populations to safe shelters and ensuring complete adherence to social distancing measures. The problem was amplified as the state of Odisha is a source of supply for laborers outside the state as well as for Gulf nations. The huge influx of migrant laborers coming into Odisha at the time of the pandemic and the cyclone hitting the state made the situation worse. But drawing on its disaster management and past experiences dealing with extremely severe cyclonic storms like Phailin, Fani, and Amphan over a decade made the state confident of managing it successfully (SRC, n.d.-a, n.d.-b, n.d.-c).

Method

The article followed a process-tracing method (George and Bennett 2005) to understand the system and how the system responds to the impact of compounding disasters. The method is appropriate as it establishes the relationship between the independent variables and outcome of the dependent variables of the study (Walch 2019). The source of empirical evidence for this article is a qualitative study consisting of four methods, including (1) focus group

discussions, (2) key informant interviews, (3) in-depth interviews, and (4) a walk-through observation with government representatives from state to block levels, international nongovernmental organizations/nongovernmental organizations (INGOs/NGOs), and with local and disaster-prone communities in the coastal district of Odisha. The details of the data collection techniques are presented in Table 2.

The authors' connections in the disaster management sector were used to reach respondents, and a snowball sampling method was administered to collect the required data (Biernacki and Waldorf 1981). Though this type of method has its limitations as it creates bias, in developing countries, using the existing network and connections is considered the only approach for reaching out to the respondents (Cammett 2006). The empirical data consist of key informant interview data of twenty-one respondents and twelve FGDs, who were generally involved in different phases of disaster management following the COVID-19 pandemic and the Amphan cyclone in Odisha. The details of techniques used in data collection and the number of participants who interacted are presented in Table 2.

Table 2: Data Collection Techniques Used and the Number of Participants

Techniques for Data Collection	*Number of Participants*
FGDs	Twelve FGDs were conducted in twelve villages in Odisha's Ganjam and Kendrapara districts. The group consisted of people from different livelihood groups who have experienced various disasters.
Key Informant Interviews with State Government Officials	Four officials from the Odisha State Disaster Management Authority (OSDMA) were interviewed on governance and management aspects.
Key Informant Interviews with District- and Block-Level Senior Officers	Ten officials from district emergency operation centers from both districts, block- and tahsil-level officers, were interviewed to understand how the system works and the unique aspects of innovation and flexibility in managing disasters.
Key Informant Interviews with NGOs/INGOs	Five officials from NGOs/INGOs were interviewed to understand coordination and teamwork aspects.
In-Depth Interviews	Key government and NGO officials who worked and experienced the transformation in the disaster-affected regions in the Ganjam and Kendrapara districts of Odisha.
Walk-Through Observation Method	At the village level, consultation with elderly persons who had experienced extreme weather events in the past decades and could share change/transformation over time was conducted.

The profile of key informants (respondents) at different levels is presented in detail in the Notes section. The field visits were conducted in March 2023 at Odisha's Kendrapara and Ganjam districts. The vulnerable blocks and seaside villages were visited for community interaction, while government officers were met in their offices, which lasted around twenty to twenty-five minutes. The FGDs with communities lasted about forty-five to sixty minutes. The nature of the interview was semi-structured, allowing authors to reflect upon some of the key questions and providing ample scope and freedom for the respondents to express as convenient.

The interactions with the government officials helped to understand how the transformation had occurred and how the system had become more equipped to handle

disasters. Some of the questions asked to the government officials were: (1) What are the strategies adopted by the government to deal with disasters? (2) Why are these strategies found to be effective on the ground? (3) How do they foresee and prepare for disasters? (4) What community-based disaster management techniques have worked in managing the disasters? (5) What are the investments made in different capitals, such as human, natural, physical, social, and financial, for strengthening the disaster management sector? (6) What are the returns from the investments made? Some of the questions asked of the communities were: (1) How have things changed from Super Cyclone 1999, and what do you think has been the government's role? (2) Do you think you are safer now than you were twenty years ago, and why do you think so? (3) During disasters, do different levels of government work as a team and collaborate with external stakeholders? (4) What type of support and services do you receive from the government during and after disasters? The answers to the aforementioned questions asked to government officials and communities are presented in the form of findings of the article in the Discussion and Analysis.

Compounding Disasters Leading to Adaptive Governance

This section attempts to provide an overview of compounding disasters across the globe and their links with adaptive governance, understanding and recognizing that multiple disaster events in one region may lead to another is necessary. Thus, a quick-time single event can become multiple, causing large-scale devastation to communities worldwide (Liu and Huang 2015).

The East Japan earthquake in 2011 is a perfect case in point to illustrate a compounding disaster and its effects on the economy. Japan's earthquake was a catastrophic disaster (Kawata 2011). This earthquake triggered a massive tsunami, which led to the destruction of the Fukushima Daiichi nuclear power plant. It caused tremendous social and economic repercussions. The authors explain that three critical characteristics of catastrophes are that they are (1) disasters-extensive, (2) compounding, and (3) prolonged. Multiple disaster events generally cause these catastrophic disasters. These catastrophic disasters are also called "compound disasters" or "double- or triple-punch disasters." Thus, any disaster can lead to a compounding process where one disaster precipitates another. Therefore, it is crucial to recognize the threats from compound disasters for designing effective disaster risk management policies.

Figure 2 highlights the disaster events that lead to the compounding effects of disasters. Examples of compounding disasters are the Super Cyclone 1999, which resulted in storm surges and torrential rains leading to devastating floods in the river basins. Cyclone Phailin hit the state in 2013, but it was of lesser magnitude, but the cumulative effects of the disaster were evident as it caused heavy rainfall and subsequent floods. The state faced another extremely severe cyclonic storm, Fani, in May 2019, which also inflicted wide-scale damage due to the compounding effects of the disaster (SRF, n.d.-b).

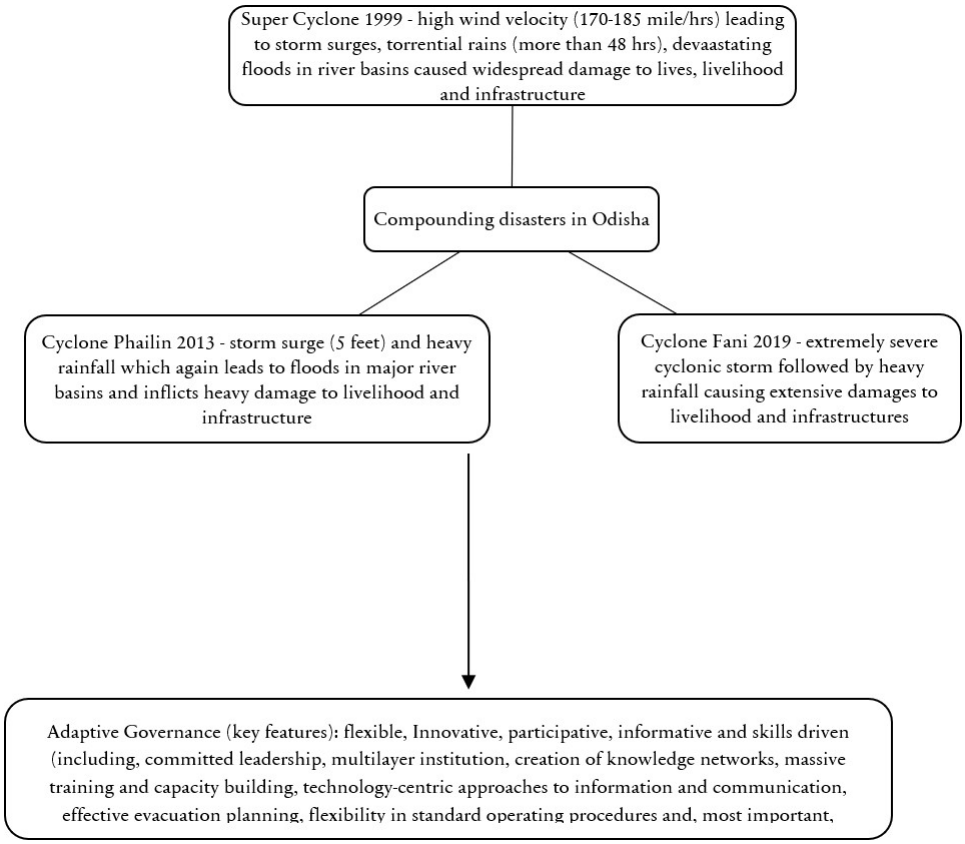

Figure 2: Compounding Disasters Lead to Adaptive Governance

However, the impact of the disasters was very different to each abovementioned event in the context of Odisha. The death toll was around 10,000 during the Super Cyclone of 1999, but it significantly reduced to approximately forty-four in cyclone Phailin (Ray-Bennett 2016). The reason for such a vast difference is due to many factors, but one of the significant aspects was adaptive governance. To make a point in this case, when the meteorological organizations announced the probable landfall of cyclone Phailin, the Government of Odisha evacuated 1 million people from eighteen districts (World Bank 2014), which is considered one of the largest evacuations in India. Thus, the Government of Odisha and its people have shown tremendous resilience to come out of the compounding effects of many disasters through its adaptive governance model. The following section explores the links between compounding disasters and adaptive governance to understand the intricacies.

During the pandemic, the world has witnessed a surge in extreme weather events that have killed 17,242 people and affected the lives of 139.2 million people in at least 433 events (Walton et al. 2021). It signifies the impact of compounding disasters on different regions in the world. Table 3 indicates that when extreme weather events overlap with the pandemic, the magnitude of the disaster that it can bring is enormous in terms of people affected and

the number of deaths. It is observed that in Europe and Central Asia, around 6,782 persons have lost their lives, and 965,047 people were affected, whereas in South Asia, 4,649 people have lost their lives. East Asia and the Pacific were equally affected, as 2,290 lost their precious lives. The case of Sub-Saharan Africa was also grim, as 1,069 people died due to disasters. These data call for an immediate discussion to understand the magnitude of devastation and challenges that compounding disasters bring in different regions. The deaths due to extreme weather events coupled with the pandemic reflect that the death figures are much higher in developed countries than in the least-developing countries.

Table 3: Impact of COVID-19 and Extreme Weather Events (till August 2021)

Regions	*Number of People Affected*	*Number of People Who Died*	*Number of Events*
Europe and Central Asia	965,047	6,782	48
South Asia	42,369,624	4,649	39
East Asia and the Pacific	24,549,246	2,290	115
Sub-Saharan Africa	46,385,202	1,369	91
North America	98,915	1,069	48
Latin America and the Caribbean	9,691,101	766	70
Middle East and North Africa	15,144,498	317	30

Source: Adapted from EM-DAT, IFRC, and Climate Centre Reports

There are many international case studies on compounding disasters in Honduras, where the effects were compounded due to two subsequent hurricanes coupled with COVID-19. The government faced the dual challenge of preventing the spread of the virus and dealing with emergencies due to cyclones (World Bank 2021). The Kenyan Government declared a drought situation during the time of the pandemic in 2021. The COVID-19 restriction further compounded the problem due to reduced production and increased food prices (Government of Kenya [GoK] 2022). A very similar event was felt in Afghanistan, as most of the country was affected by drought in 2021 (International Federation of Red Cross and Red Crescent Societies [IFRC] 2021). Another significant example of compounding disasters is when cyclone Amphan affected three countries (India, Bangladesh, and Sri Lanka) during COVID-19 and destroyed lives and livelihoods (Priodarshini et al. 2021); but the point here is that in India (and especially in Odisha), thanks to a robust disaster management approach, there were no lives lost, though livelihood was affected to some extent (SRF, n.d.-c).

The literature on compounding disasters reveals how disasters striking simultaneously create enormous challenges for governments worldwide. The challenges faced are evacuation, creation of temporary shelters in safe locations, proper and adequate arrangement of food and water, hygiene and recovery, and reconstruction aspects in a post-disaster scenario. However, the statistics on fatalities and casualties have increased with each passing disaster worldwide; but the question here is how some countries' governments manage the disaster so that the deaths are much less than in other countries. In this context, the key elements of adaptive governance are critical in addressing disaster-associated uncertainties.

The principle of adaptive governance is deeply rooted in work undertaken by Holling (1973), which focuses on the socio-ecological and adaptive systems perspective. The changes in the environment are very dynamic and complex, and they require governance systems to be more adaptive to respond to these changes (Folke 2006). The concept of adaptive co-management is built upon trust, collaboration, institutional development, and social learning (Armitage, Berkes, and Doubleday 2007). The key elements of adaptive co-management include innovative and flexible institutional structures, providing incentives, learning and regular monitoring, and assessing the interventions (Armitage, Berkes, and Doubleday 2007).

Adaptive governance, often called polycentric governance, is a governance system that can transform and change existing practices to incorporate new learning and experiences in the system to respond to emerging threats from climate change and other uncertainties (Shinn 2016). Polycentric governance is better understood when linked to a monocentric form (Ostrom, Tiebout, and Warren 1961). A monocentric form of governance is a centralized system of operation, generally controlled by one authority. Even so, polycentric governance has many governing layers at varying levels, and they help in innovation, learning, and in the spread of knowledge at different levels in the organization (Ostrom 2010).

Research on environmental governance indicates that an adaptive form of governance handles uncertainty far better than any other form of government, thus best suited to deal with climate emergencies (Huitema et al. 2009; Bogardi et al. 2012; Pahl-Wostl and Knieper 2014). Drawing from Ostrom's work on the management of common-pool resources and governance in the context of climate change, the key elements for adaptive governance were identified (Dietz, Ostrom, and Stern 2003). These are information, resolution of conflicts, compliance with rules, provision of infrastructure, and adaptation. With the backdrop of these key elements, polycentric institutions enable experimentation, learning, and change (Dietz, Ostrom, and Stern 2003).

Drawing the international experiences from Sweden and Australia reflects adaptive governance, paving the way for collaboration in different institutional structures (Schultz et al. 2015). However, since the applicability of adaptive governance remains difficult in developing economies (Shinn 2016), the pertinent question is under what conditions the traditional governance systems become adaptive.

Walch (2019), in his paper, attempts to answer this question through the successful case of Odisha, India. He argues that a traumatic shock followed by committed political leadership can transform governance practices and adopt a more flexible and innovative approach to governance. Forest fires are a global phenomenon affecting not only the forest-dependent communities but the entire forest ecosystem and sectors dependent on it. In Australia, forest fires, specifically bushfires, are critical disaster management challenges as these fires destroy the forest ecosystem. In this context, adaptive governance has emerged as a model to address socio-ecological issues in disasters (Ruane 2019).

Adaptive governance is best suited to deal with uncertainties associated with climate change and natural disasters, focusing on collaboration, learning, and flexibility. The literature on adaptive governance has one fundamental gap: these theories often neglect many of the

ground realities of implementing adaptive governance systems (Shinn 2016) and take note of the well-functioning adaptive systems, particularly from emerging economies like India. In this context, the presence of different government institutions at various levels helps to undertake distinct functions at a precise and greater scale (McGinnis 1999). Specifically, polycentric and multilayered institutions possess the capacity to build and strengthen resilience. The disaster literature indicates the significance of participation and collaboration by a wide array of stakeholders, particularly in the pre-disaster phases (Macrae and Hodgkin 2011).

In a self-organized and informal governance system, many actors work together across organizational levels to solve fundamental problems. INGOs play a significant role in vulnerability and disaster risk reduction. This set of organizations has tremendous flexibility in their operations and resource deployment, as they do not have the bureaucratic structure that the formal government usually possesses, thus enabling communities to deal with the various stages of disasters. In this context, the concept of adaptive governance and its key elements come into the picture.

Disaster Management—Institutional Structure

This section presents the institutional structure of disaster management in Odisha. It highlights the role of different layers in the institutional structure and how the flow of information is disseminated down the line. The section helps to understand the other factors that significantly reduce and mitigate disaster risk in the state.

The institutional structure of disaster management at the state level consists of the State Disaster Management Authority (SDMA) and the State Executive Committee (SEC). The SDMA is constituted under sections 14 to 24 of the Disaster Management Act, 2005. The Chief Minister of the state is the Ex-officio Chairman of the SDMA. The SEC is constituted under sections 20 and 21 of the Disaster Management Act, 2005. The Chief Secretary is the Chairperson of the Committee. The SDMA and SEC are involved in planning and policy formulation. The critical institutions/departments for disaster management in the state are the Revenue and Disaster Management Department, Special Relief Organization, and OSDMA.

The Special Relief Organization (SRO), headed by the Special Relief Commissioner (SRF), plays a key role in disseminating warnings to the last person through its state-of-the-art technological infrastructure, and it looks after relief and rescue operations. The space-based support organization plays a crucial role in forecasting and predicting events. Another key organization in disaster management is OSDMA, which undertakes many training and capacity-building activities, from Odisha Disaster Rapid Action Force (ODRAF) training to community-level volunteers in different disaster response activities. It also plays a significant role in the rebuilding and reconstruction phases in the aftermath of a disaster. It undertakes activities related to mitigation and adaptation in the context of changing climate dynamics.

Another key organization in the structure is the District Disaster Management Authority (DDMA), headed by the collector (the head of the district) as it disseminates information down

the line and takes preventive and evacuation action based on the predictions and warnings received from the state government. The strength of the institutional structure lies in creating a solid knowledge network and links within and outside the system. The DDMA is a crucial institution at the district level for managing disasters. It has state-of-the-art infrastructure, skilled human resources, regular training, and capacity buildings. The Block Development Officer (BDO) and Tahsildar are the two government officers responsible for managing disasters at the block level. They supervise the shelter-level readiness, community kitchens, and other aspects of preparedness, mainly shifting pregnant women and other vulnerable populations (such as aged men and women, disabled people, and children) to safe locations/hospitals and keeping ambulances and additional support ready to attend to any health emergency. The flowchart representation of the institutional arrangements is presented in Figure 3.

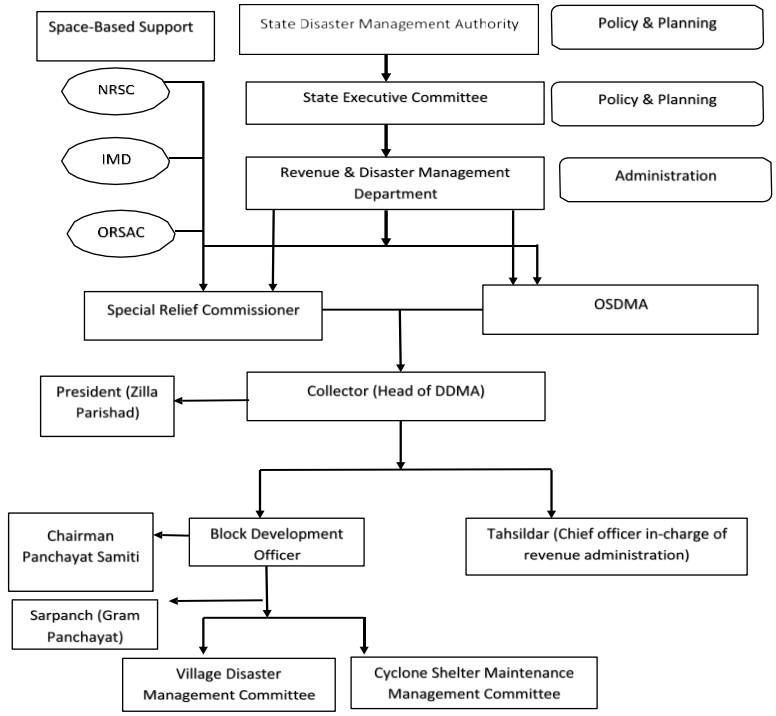

Figure 3: Flowchart Representation of Disaster Management—Institutional Arrangements

Source: Adapted from OSDMA documents; IMD: Indian Meteorological Department; NRSC: National Remote Sensing Centre; ORSAC: Odisha Space Application Centre

Discussion and Analysis

This section, first, provides insights into the key elements of adaptive governance concerning disasters. Second, it captures the government officials and community viewpoints to corroborate the literature-level findings on the links between compounding disasters and adaptive governance. It also brings in the key strategies adopted by the Government of Odisha to strengthen the disaster management landscape in the state.

Multilayer Institutions

The multilayer institutional arrangement presented in Figure 3 highlights the networks and links the state built and developed in the aftermath of the Super Cyclone in 1999. The relief administration arrangement has multiple layers from the state to the panchayat level. Interaction with government officials at the state, district, and block levels indicates that the committed political leadership (Walch 2019) and vision of the state that "every life is precious" is so deeply rooted in the system that all government officials are fully committed to saving lives—they go beyond the call of duty. Field-level interactions also reveal that all the stakeholders understand their roles and responsibilities. A strong teamwork and coordinated approach is deeply ingrained in the government functionaries, communities, and NGOs/INGOs, making the state of Odisha disaster-resilient.

To quote a statement from a Government Officer:

> A senior officer visited nine tahsils (approximately in a single day to ensure the disaster readiness of the district and evacuations in the vulnerable pockets." (Source: Field interaction with government officials)

Interaction with the communities reveals that:

> The government is very much committed to saving lives. It is in this context whenever a cyclone is in the reckoning, the authorities ensure preparedness at cyclone shelters and safe buildings, and vulnerable communities are evacuated and kept in these shelters with all basic amenities. (Respondent from a seaside village in Rajnagar block of Kendrapara district in Odisha)

The vulnerable communities residing in the hazard-prone zones are of the view that they feel much safer than twenty years back due to the government's holistic strategy to deal with disasters. The communities are of the view that the government has invested heavily in building cyclone shelters, training and capacity building, and other preparedness measures. The implementation of structural adaptations and vulnerability reduction measures, such as the construction of concrete houses and the promotion of alternative livelihood diversification for communities reliant on climate-sensitive sectors, has significantly aided these communities in effectively adapting to shifting climate dynamics and mitigating the impact of disasters. The communities also feel that during pre- and post-disasters situations, the different levels of government work as a team and collaborate with other stakeholders such as NGOs and INGOs to provide all the basic necessities during that period (FGDs with communities in Ganjam and Kendrapara districts of Odisha).

Thus, when the state of Odisha faced the pandemic and subsequent cyclone, the multilayer strong institutions were one of the strengths of the Government of Odisha. Odisha reported the first case of COVID-19 on March 15, 2020. By bringing its long-term experience

in handling disasters and adopting its disaster model and its relief operation pattern, the state could respond to the pandemic crisis very effectively. It took proactive measures very early to contain the virus and address the disruptions to livelihood, health, and economy in the most suitable way. To save lives during a disaster, the Government of Odisha has created around 824 multipurpose cyclone and flood shelters across all vulnerable pockets in the state. These shelters provided all types of basic amenities required during an emergency. They were handy during the pandemic and provided quarantine and temporary medical center facilities to the large number of migrant people coming back to Odisha. Field interactions with block-level officials reflected that the shelters saved lives as they provided food and helped to maintain the social distancing norms during a pandemic. To deal with the pandemic more efficiently, the state government formed the state and district crisis committee to make policy decisions on spread and containment with proper institutional mechanisms, which eventually helped reduce the infection rates in Odisha.

Learning and Innovation

The 1999 Super Cyclone was a traumatic shock (Walch 2019) for the people of Odisha, as it resulted in the death of approximately 10,000 people and caused widespread destruction across social and economic sectors. This shock led to tremendous learning and innovation from the government, as it was the first in the country to set up a dedicated institution for managing and preparing for disasters. It led to the setting up of the OSDMA. It was followed by continuous investment in strengthening the capacity of systems and using people in a consultative and participatory manner. The state invested in setting and strengthening early warning systems through the adoption of cutting-edge technologies and fostering partnerships with international agencies to reduce the death toll due to various disasters. In this pursuit, the state government collaborated with Regional Integrated Multi-Hazard Early Warning Systems (RIMES) in Thailand for the implementation of one-stop risk management systems, as it provides early warning information in case of disasters. The Government of Odisha has launched a mobile-based application named SATARK (System of Accessing, Alerting Disaster Risk Information based on Dynamic Risk Knowledge). The mobile application helps to provide real-time information on disasters (OSDMA, n.d.-b).

One of the key discoveries from Super Cyclone 1999 was that cyclone shelters can save lives. So, in this regard, the Government of Odisha has constructed over 824 multipurpose cyclone/flood shelters across all vulnerable and hazard-prone zones in Odisha (interaction with state-level officials and information extracted from www. Osdma.org). During the 1999 Super Cyclone, the state was ill-equipped in preparedness and response. So, to strengthen the response skills, the state government decided to set up a dedicated response force to deal with the disaster. In this context, the ODRAF came into being. The state invested heavily in strengthening the skills and infrastructure of ODRAF and fire services.

The Odisha government, with support from the World Bank, has constructed disaster-resilient housing within 5 km of the high tide line. The concrete houses would strengthen the physical asset base of the coastal communities residing close to the sea.

Plans, Policies, and Procedures

The state government has put a system that requires the preparation of detailed disaster management plans by all the departments of the government. It includes assessment of risk and vulnerability, identification of disaster-prone areas, standard operating procedures that clearly indicate what needs to be done before and after disasters, responsibility of different government functionaries, directory of key institutions, and training and capacity building of key responders (PricewaterhouseCoopers [PwC] and Observer Research Foundation [ORF] 2023). The Government of Odisha was the first in the country to develop a state-specific climate change action plan in 2009. The Odisha Climate Change Action Plan (OCCAP) outlines strategies to counter the negative impacts of climate change through appropriate mitigation and adaptation strategies across critical sectors affected by most of the changing climate dynamics (Department of Forest, Environment and Climate Change [DFECC], n.d.). The plans and policies focused on addressing issues at the village level. The Village Disaster Management Plan (VDMP) is prepared in consultation with the affected communities to comprehensively understand the nuances of managing disasters at the village level. The situational analysis, hazard, risk and vulnerability profiling, and identifying the at-risk populations such as children, women, and the elderly population makes the plan a robust one. OSDMA has helped in the preparation of such plans in 10,000 villages in Odisha in the first phase, and, subsequently, in the second phase of VDMP, another 10,000 villages' plans are being prepared. Simultaneously, the gram panchayat and block-level plans are prepared to holistically address all disaster risk-reduction issues. Standard operating procedures for all the notified disasters are prepared and shared with all the stakeholders. This helps immensely during disasters.

The lessons learned from disaster management helped the government address the compounding effects of disasters. The Government of Odisha resorted to the approach of decentralization of COVID-19 prevention and control. The disaster management experience of the state government led to decentralized prevention and mitigation response. The Panchayati Raj Institutions (PRIs) were empowered based on Section 22H of the Disaster Management Act, 2005, and the Gram Panchayat or the sarpanch was notified as an authority with executive powers to redress the impact of COVID-19 under their jurisdiction, in line with the powers of District Collectors. Empowering local authorities and PRIs expedited decision-making and programme implementation processes, enabled swift response at the ground level, and provided greater outreach. In particular, the Gram Panchayats played an essential role in managing the movement of migrants and managing temporary medical centers for them.

Networks

The state government also helped in the creation of self-organized groups and networks to oversee the disaster risk-reduction measures that are owned and managed locally. The networks and collaboration created with communities, INGOs, and state NGOs have helped in various stages of disaster risk reduction. The United Nations organizations (UNDP, UNICEF), Inter-Agency Group, and the Red Cross work closely with OSDMA.

The most significant aspect of the network is the relationship with the community. As communities are the first responders, the government approach has been community-based disaster preparedness (CBDP) for effectively managing disasters. CBDP refers to preparedness, mitigation, and response plans. The state government has taken the initiative in identifying community-level volunteers and training them in disaster response skills. Women's participation in CBDP has been given due importance, and women also participate in preparedness and mitigation initiatives. In Odisha, the vulnerable communities are actively engaged in disaster management through training and capacity-building exercises by governmental and nongovernmental entities. However, community preparedness goes beyond participation; it involves collaborative efforts between community members and local and national disaster authorities (Bose 2020).

Community participation in disaster management ensures ownership and understanding of local vulnerabilities. It promotes a culture of social cohesion among the community members, which helps deal with disasters. OSDMA has played a critical role in creating community-level volunteers trained in disaster management, such as search and rescue and first aid. This experience of community-level volunteers has been beneficial during the pandemic, as it helped build community outreach.

Government and NGO Coordination

The Disaster Management Act, 2005, and National Disaster Management Policy, 2009, clearly mention the role of NGOs and how NGOs can supplement the efforts of the government to help communities in coping with disasters. The NGOs play a significant role in all aspects of disaster management. The current trend in this aspect reveals that NGOs acts as a facilitator between the administration and the affected community. The reason is that they have a grassroots presence and strong links with the needs of the affected community. Government and NGO coordination has been one of the critical pillars of strength for managing disasters in the state. The NGOs are involved in pre- and post-disaster management stages. They also support the training and capacity building of community-level volunteers, cyclone shelter maintenance and management committees, and other vital tasks. NGOs support the government in undertaking village-level vulnerability assessments with respect to the preparation of disaster management plans.

Decentralized Decision-Making and Compliances of Rules

The Government of Odisha has amended the Odisha Gram Panchayat Act, 1964, to involve and own the responsibility of planning, preparedness, and undertaking mitigation measures for the PRI members. It paves the way for decentralized decision-making at the panchayat level. The law-and-order situation is a critical component during and after disasters. Odisha was India's first state to impose a lockdown at the pandemic's start. For pandemic management, strict rules were enforced in Odisha, leading to fewer infection rates and deaths compared to other states in India.

Information

To minimize the compounding effects of disaster, Odisha has created a technological infrastructure and continuously upgrades it. It has a state-of-the-art "State Emergency Operation Center" with necessary space-based support from national and international organizations. Technological advancement in the field of Early Warning Dissemination Systems (EWDS) with national and international partnerships to achieve timely predictions has made it possible to strengthen preparedness measures. EWDS stands for "last-mile connectivity," which aims to disseminate information from the state, district, and block levels to communities and vice versa, ensuring that the last person living near the sea is well-informed of an upcoming cyclone or tsunami. The EWDS consists of all modern communication technologies, such as digital mobile technology, satellite-based communication, and location-based and mass messaging systems (OSDMA, n.d.-a). The forecasts, alerts, and warnings issued by the Indian Meteorological Department (IMD) with technological advancement have supported reducing the time-lapse for early warning dissemination. It indicates the state's capabilities in preparing for and facing disasters.

Capacity Building

The Government of Odisha took a historic step in strengthening the capacities of all in disaster management. A Resolution of the Council of Ministers on May 29, 2021, was passed to develop a task force on disaster and pandemic management to guide the state in future preparedness. Disaster management is being included in the curriculum in schools and colleges to enable a formidable force of disaster management volunteers to strengthen the state's efforts in managing disasters. Besides, all elected representatives, from Chief Minister to corporators and ward members and from Chief Secretary to lowest level functionaries, will be trained in several aspects of disaster and pandemic management (*New Indian Express* [TNIE] 2021).

Mitigation and Adaptation Interventions

The disaster-resilient infrastructure with a Building Back Better approach to reducing the damage to infrastructure, property, and assets is of utmost importance. The state of Odisha has started to work for Building Back Better and has prepared a long-term investment plan for disaster-resilient

power infrastructure and coastal embankment protection using capital embankment construction along with shelter belt plantation with mangroves and casuarina species all along the Odisha coast. Mangroves are regarded as natural barriers against cyclones and storm surge protection. The India State of Forest Report 2021 highlights the increase in mangrove cover in Odisha because the area has increased by 8 km^2 from 2019 to 2021 through natural regeneration and plantation activities. This will help in building the overall resilience of the state.

Conclusion

The link between adaptive governance and compounding disasters reflects that the negative impacts of disasters could be minimized by adopting an adaptive form of governance. Implementing critical elements of adaptive governance, such as multilayer institutions, learning and innovation, networks, information, compliance of rules, and provision of essential infrastructure, has started the journey for Odisha to a disaster-resilient state soon. The state approach has been focused on creating a culture of prevention, preparedness, and achieving resilience through investing in risk assessments, tools and technologies, awareness, training and capacity building, strengthening governance systems, early warning systems, risk-informed programming, contingency plans, information sharing, and sustainable development.

The Odisha disaster management model has successfully reduced the number of deaths due to disasters. The government zero-casualty approach has received accolades from all sections of society and received awards and recognitions from the national government and the United Nations. Thus, the first key lesson from Odisha's disaster management model is that the deaths can be reduced, in some cases to zero, if the system is innovatively aligned with the vision of "every life is precious." The second lesson is proper and effective dissemination of disaster warnings to the last mile and a flexible, time-effective response system. The third meaningful lesson is inculcating a culture of preparedness and capacity building among all the key stakeholders.

It is time now that Odisha moves from zero deaths to a more holistic approach to managing disasters. It calls for strengthening and building the disaster-resilient infrastructure, that is, disaster-resilient houses and disaster-resilient power infrastructures. Another critical area that needs to be explored is how shock-responsive social protection systems help strengthen disaster resilience. During the pandemic, the social protection systems were a potent instrument for governments worldwide to reach the poor and marginalized sections of society with food, cash, and other benefits.

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Informed Consent

The authors have obtained informed consent from all participants.

Conflicts of Interest

The authors declare that there is no conflict of interest.

Notes

- Government of Odisha officials: Officials, OSDMA; Officials, District Emergency Operation Center at Ganjam and Kendrapara; Additional Block Development Officer, Rajnagar, Kendrapara, Government of Odisha; Tahsildar, Rajnagar, Kendrapara, Government of Odisha; District Project Officers, Ganjam and Kendrapara
- INGOs and NGOs
- Local NGOs and community organizations: Secretary, Nature's Club; Executive Director, VIEWS, Gopalpur; Project Director, VIEWS, Gopalpur; Representative, Fisher Folks Organization; Coordinator, Shelter Management Committees; Representative, Fisher Folks Organization
- Focus Group Discussions (FGDs): Women, elderly persons, and youths in the vulnerable villages
- Zilla Parishad, chairman (known as the District Councils, where chairperson or president is elected among other members); Panchayat Samiti, president (a rural local government body); Gram Panchayat, sarpanch (the village council is the gram panchayat, the village governing institution); Tahsil (a district administration or revenue subdivision in India)

REFERENCES

Armitage, Derek, Fikret Berkes, and Nancy Doubleday, eds. 2007. *Adaptive Co-Management: Collaboration, Learning and Multi-Level Governance*. Vancouver, Canada: UBC Press.

Biernacki, Patrick, and Dan Waldorf. 1981. "Snowball Sampling: Problems and Techniques of Chain Referral Sampling." *Sociological Methods & Research* 10 (2): 141–163. https://doi.org/10.1177/004912418101000205.

Bogardi, Janos, David Dudgeon, Richard Lawford, Eva Flinkerbusch, Andrea Meyn, Claudia Pahl-Wostl, Konrad Vielhauer, and Charles Vörösmarty. 2012. "Water Security for a Planet under Pressure: Interconnected Challenges of a Changing World Call for Sustainable Solutions." *Current Opinion in Environmental Sustainability* 4 (1): 35–43. https://doi.org/10.1016/j.cosust.2011.12.002.

Bose, Sohini. 2020. "Following the Odisha Example for Developing Community Based Disaster Management in India." *Observer Research Foundation (ORF)* (blog). September 4, 2020. https://www.orfonline.org/expert-speak/following-the-odisha-example-for-developing-community-based-disaster-management-in-india/.

Cammett, Melani. 2006. "Political Ethnography in Deeply Divided Societies." *Qualitative Methods* 4:1–32. https://doi.org/10.5281/zenodo.997393.

Chaffin, Brian, Hannah Gosnell, and Barbara Cosens. 2014. "A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions." *Ecology and Society* 19 (3): 56. https://doi.org/10.5751/ES-06824-190356.

Cutter, Susan. 2018. "Compound, Cascading, or Complex Disasters: What's in a Name?" *Environment: Science and Policy for Sustainable Development* 60 (6): 16–25. https://doi.org/10.1080/00139157.2018.1517518.

DES (Directorate of Economics and Statistics), Government of Odisha. n.d. *Odisha Economic Survey (OES), 2021–22*. Odisha, India: DES, Government of Odisha. Accessed March 15, 2023. http://www.desorissa.nic.in/latest_publications.html.

DFECC (Department of Forest, Environment and Climate Change), Government of Odisha. n.d. *Odisha Climate Change Action Plan*. Odisha, India: DFECC, Government of Odisha. Accessed March 15, 2023. https://climatechangecellodisha.org/.

Dietz, Thomas, Elinor Ostrom, and Paul C. Stern. 2003. "The Struggle to Govern the Commons." *Science* 302 (5652): 1907–1912. https://doi.org/10.1126/science.1091015.

Djalante, Riyanti, Cameron Holley, and Frank Thomalla. 2011. "Adaptive Governance and Managing Resilience to Natural Hazards." *International Journal of Disaster Risk Science* 2 (4): 1–14. https://doi.org/10.1007/s13753-011-0015-6.

Djalante, Riyanti. 2012. "Review Article: 'Adaptive Governance and Resilience: The Role of Multi-Stakeholder Platforms in Disaster Risk Reduction.'" *Natural Hazards and Earth System Sciences* 12:2923–2942. https://doi.org/10.5194/nhess-12-2923-2012.

Folke, Carl. 2006. "Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses." *Global Environmental Change* 16 (3): 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002.

George, Alexander L., and Andrew Bennett. 2005. *Case Studies and Theory Development in the Social Sciences*. Cambridge, MA: MIT Press.

GoK (Government of Kenya). 2022. *The 2021 Short Rains Season Assessment Report*. Nairobi, Kenya: Kenya Food Security Steering Group, GoK. https://reliefweb.int/report/kenya/kenya-2021-short-rains-season-assessment-report-february-2022.

Holling, C. S. 1973. "Resilience and Stability of Ecological Systems." *Annual Review of Ecology and Systematics* 4 (1): 1–23. https://doi.org/10.1146/annurev.es.04.110173.000245.

Huitema, Dave, Erik Mostert, Wouter Egas, Sabine Moellenkamp, Claudia Pahl-Wostl, and Resul Yalcin. 2009. "Adaptive Water Governance: Assessing the Institutional Prescriptions of Adaptive (Co-)Management from a Governance Perspective and Defining a Research Agenda." *Ecology and Society* 14 (1): 26. https://digitalcommons.usu.edu/unf_research/27.

IFRC (International Federation of Red Cross and Red Crescent Societies). 2021. *Afghanistan: Worst Drought and Hunger Crisis in Decades*. Geneva, Switzerland: IFRC. https://www.ifrc.org/press-release/afghanistan-worst-drought-and-hunger-crisis-decades.

IPCC (Intergovernmental Panel on Climate Change). 2021. *Climate Change 2021: The Physical Science Basis*. Working Group I, Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. The IPCC Secretariat, Geneva: United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO). https://report.ipcc.ch/ar6/wg1/IPCC_AR6_WGI_FullReport.pdf.

IPCC (Intergovernmental Panel on Climate Change). 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Working Group II, Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. The IPCC Secretariat, Geneva: United Nations Environment Programme (UNEP) and World Meteorological Organization (WMO). https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf.

Kawata, Yoshiaki. 2011. "Downfall of Tokyo due to Devastating Compound Disaster." *Journal of Disaster Research* 6 (2): 176–184. https://doi.org/10.20965/jdr.2011.p0176.

Liu, Minquan, and Michael C. Huang. 2015. *Compound Disasters and Compounding Processes Implications for Disaster Risk Management*. Tokyo, Japan: United Nations Office for Disaster Risk Reduction, National Graduate Institute for Policy Studies, Asian Development Bank Institute. https://www.semanticscholar.org/paper/COMPOUND-DISASTERS-AND-COMPOUNDING-PROCESSES-for-LiuHuang/0526d99aed2d373a39dade810a908c2ef6547be4.

Macrae, Graeme, and David Hodgkin. 2011. "Half Full or Half Empty? Shelter after the Jogjakarta Earthquake." *Disasters* 35 (1): 243–267. https://doi.org/10.1111/j.1467-7717.2010.01202.x.

McGinnis, Michael Dean. 1999. *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: University of Michigan Press.

NITI (National Institution for Transforming India), Government of India. 2023. *India-National Multidimensional Poverty Index-2023*. New Delhi, India: NITI Aayog. https://niti.gov.in/sites/default/files/2023-08/India-National-Multidimentional-Poverty-Index-2023.pdf.

Olsson, Per, Carl Folke, and Fikret Berkes. 2004. "Adaptive Comanagement for Building Resilience in Social-Ecological Systems." *Environmental Management* 34 (1): 75–90. https://doi.org/10.1007/s00267-003-0101-7.

OSDMA (Odisha State Disaster Management Authority). n.d.-a. *Early Warning Dissemination System (EWDS)*. Odisha, India: OSDMA. Accessed March 21, 2023. https://www.osdma.org/preparedness/early-warning-communications/ewds/#gsc.tab=0.

OSDMA (Odisha State Disaster Management Authority). n.d.-b. *One Stop Risk Management System*. Bhubaneswar, India: OSDMA. Accessed March 16, 2023. https://www.osdma.org/preparedness/one-stop-risk-management-system/.

Ostrom, Elinor. 2010. "Polycentric Systems for Coping with Collective Action and Global Environmental Change." *Global Environmental Change* 20 (4): 550–557. [20th Anniversary Special Issue]. https://doi.org/10.1016/j.gloenvcha.2010.07.004.

Ostrom, Vincent, Charles M. Tiebout, and Robert Warren. 1961. "The Organization of Government in Metropolitan Areas: A Theoretical Inquiry." *American Political Science Review* 55 (4): 831–842. https://doi.org/10.2307/1952530.

Pahl-Wostl, Claudia, and Christian Knieper. 2014. "The Capacity of Water Governance to Deal with the Climate Change Adaptation Challenge: Using Fuzzy Set Qualitative Comparative Analysis to Distinguish between Polycentric, Fragmented and Centralized Regimes." *Global Environmental Change* 29:139–154. https://doi.org/10.1016/j.gloenvcha.2014.09.003.

Pescaroli, Gianluca, and David Alexander. 2015. "A Definition of Cascading Disasters and Cascading Effects: Going beyond the 'Toppling Dominos' Metaphor." *Planet@Risk* 3 (1): 58–67. https://www.semanticscholar.org/paper/A-definition-of-cascading-disasters-and-cascading-Pescaroli-Alexander/06074f128dfc90ea9adb5d54b629bcc586199089.

Pescaroli, Gianluca, and David Alexander. 2018. "Understanding Compound, Interconnected, Interacting, and Cascading Risks: A Holistic Framework." *Risk Analysis* 38 (11): 2245–2257. https://doi.org/10.1111/risa.13128.

Priodarshini, Rup, Bangkim Biswas, Ana Mariá Sánchez Higuera, and Bishawjit Mallick. 2021. "Livelihood Challenges of 'Double Strike' Disasters: Evidence from Rural Communities of Southwest Coastal Bangladesh during the Covid-19 Pandemic and Cyclone Amphan." *Current Research in Environmental Sustainability* 3:1–11. https://doi.org/10.1016/j.crsust.2021.100100.

PwC (PricewaterhouseCoopers), and ORF (Observer Research Foundation). 2023. *Climate, Community, Cooperation: An Indian Approach to Adaptation in the Global South*. India: PwC. https://www.pwc.in/assets/pdfs/climate-community-cooperation.pdf.

Ray-Bennett, Nibedita. 2016. "Learning from Deaths in Disasters: The Case of Odisha, India." Middle East Institute, June 9, 2016. http://www.mei.edu/content/map/learning-deaths-disasters-case-odishaindia.

Ruane, Simone. 2019. "Applying the Principles of Adaptive Governance to Bushfire Management: A Case Study from the South West of Australia." *Journal of Environmental Planning and Management* 63 (7): 1–26. https://doi.org/10.1080/09640568.2019.1648243.

Schultz, Lisen, Carl Folke, Henrik Österblom, and Per Olsson. 2015. "Adaptive Governance, Ecosystem Management, and Natural Capital." *Proceedings of the National Academy of Sciences of the United States of America* 112:7369–7374. https://doi.org/10.1073/pnas.1406493112.

Shinn, Jamie. 2016. "Adaptive Environmental Governance of Changing Social-Ecological Systems: Empirical Insights from the Okavango Delta, Botswana." *Global Environmental Change* 40:50–59. https://doi.org/10.1016/j.gloenvcha.2016.06.011.

Simpson, Nicholas P., Katharine J. Mach, Andrew Constable, Jeremy Hess, Ryan Hogarth, Mark Howden, Judy Lawrence, et al. 2021. "A Framework for Complex Climate Change Risk Assessment." *One Earth* 4 (4): 489–501. https://doi.org/10.1016/j.oneear.2021.03.005.

SRC (Special Relief Commissioner), Government of Odisha. n.d.-a. *Annual Report on Natural Calamities 2013–2014*. Odisha, India: SRF. Accessed March 24, 2023. https://srcodisha.nic.in/annualReport/dD4aVH69AnnualReport2013-14.pdf.

SRC (Special Relief Commissioner), Government of Odisha. n.d.-b. *Annual Report on Natural Calamities 2019–2020*. Odisha, India: SRC. Accessed March 24, 2023. https://srcodisha.nic.in/annualReport/JHLGu3hOAnnual%20Report%20on%20NC%202019-20_compressed.pdf.

SRC (Special Relief Commissioner), Government of Odisha. n.d.-c. *Annual Report on Natural Calamities 2020–2021*. Odisha, India: SRF. Accessed March 24, 2023. https://srcodisha.nic.in/annualReport/DZF3NXfMAnnual%20Report%20on%20NC%202020-21%20-REVISED%20(1).pdf.

TNIE (*New Indian Express*). 2021. "A Yodha in Every Home: Naveen Government Mantra for Disaster-Ready Odisha." *New Indian Express*, May 30, 2021. https://www.newindianexpress.com/states/odisha/2021/may/30/a-yodha-in-every-home-naveen-government-mantra-for-disaster-ready-odisha-2309450.html.

Walch, Colin. 2019. "Adaptive Governance in the Developing World: Disaster Risk Reduction in the State of Odisha, India." *Climate and Development* 11 (3): 238–252. https://doi.org/10.1080/17565529.2018.1442794.

Walton, Dan, Julie Arrighi, Maarten van Aalst, and Marie Claudet. 2021. *The Compound Impact of Extreme Weather Events and COVID-19*. Geneva: International Federation of Red Cross and Red Crescent Societies (IFRC) and Red Cross Red Crescent Climate Centre. https://www.ifrc.org/sites/default/files/2021-09/RCCC%20IFRC%20Climate%20disasters%20COVID-20210910_V2.pdf.

World Bank. 2014. "India Averts Devastation from Cyclone Phailin." *World Bank,* April 10, 2014. https://www.worldbank.org/en/results/2014/04/10/india-averts-cyclone-phailin-devastation.

World Bank. 2021. *An Unprecedented Response to an Unprecedented Disaster in Honduras*. January 11, 2021. Honduras: World Bank. https://www.worldbank.org/en/news/feature/2021/01/11/respuesta-honduras-desastre-huracanes-eta-iota.

Zscheischler, Jakob, Seth Westra, Bart J. J. M. van den Hurk, Sonia I. Seneviratne, Philip J. Ward, Andy Pitman, Amir AghaKouchak, et al. 2018. "Future Climate Risk from Compound Events." *Nature Climate Change* 8 (6): 469–477. https://doi.org/10.1038/s41558-018-0156-3.

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