

Review

An Analytical Framework for Assessing Context-Specific Rural Livelihood Vulnerability

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Abstract: Reviewing both conceptual and empirical studies on climate vulnerability and adaptation assessment, this paper offers an analytical framework to help better understand how context-specific adaptation strategies could be developed. The framework systematically assembles the Sustainable Rural Livelihoods and the Vulnerability Assessment frameworks to develop its structural and analytical components. The resulting five-step approach involves: (i) identification of context along with understanding what aspect of vulnerability need to be studied; (ii) assessment of livelihood exposure to climate impacts involving both community perspectives and meteorological data-based climate forecasts; (iii) characterization of available capital asset usages to help buffer climate sensitivity; (iv) analysis of formal and informal institutional impetus to enhance adaptive capacity; and (v) evaluation of gaps between context-specific vulnerability and institutional and policy responses to avoid maladaptive trajectories. Drawing on published research and policy documentation, we apply the framework to the livelihood systems operating in the northeastern floodplain community of Bangladesh to demonstrate the utility of the approach and then discuss its potential to inform adaptation strategies.

Keywords: natural resource systems; maladaptation; poverty; scale; developing areas; climate stress; climate change; public policy; sustainable development

1. Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), climate vulnerability is defined as “... the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change” [1]. Climate vulnerability is a complex and dynamic policy challenge, interacting with social, political, economic and ecological factors at global, regional, national and local scales [2,3]. The interpretation of climate vulnerability therefore differs across sectors and contexts [4]. Despite the complex nature of climate vulnerability, governments and communities internationally are taking actions to help support climate adaptation, defined by the IPCC as “the process of adjustment to actual or expected climate and its effects” [5]. The IPCC Working Group II Fifth Assessment Report noted that different regions are responding to the impacts of climate change through climate-sensitive decision-making in diverse ways [5]. This reflects the growing understanding of climate uncertainties, the types of resources available for different actions and the socio-political dynamics in different contexts [2,6].

Despite the global agreement and active involvement and interventions of global leadership on climate change, sufficient advancements have not been made to meaningfully regulate the human drivers of climate change [7]. Many climate stresses are known to result in persistent poverty,

socio-economic disparity and continued loss of lives, livelihoods and resources, particularly among the rural smallholders of developing countries [8,9]. While international efforts generally struggle to bring meaningful change, more locally-based adaptation measures, often emerging from the joint interventions of governments, non-government organizations and affected communities, are making significant contributions to adaptation in response to climate stresses [10]. There is, however, a need to further understand the potential for public policy institutions to deliver more localized approaches to enhancing livelihood sustainability in the face of climate change impacts [11]. Such understanding can be facilitated by more precise identification of context-specific knowledge gaps and livelihood vulnerability assessment that can reduce the maladaptation risk of policy-making [12]. However, some of the most widely adopted approaches to vulnerability assessment, including those undertaken by the IPCC, have taken a 'top-down' approach to understanding vulnerability [13]. Under this framing, vulnerability is conceptualized as an outcome of climate change that can be offset by different adaptation measures. This outcome-based framing often uses different greenhouse gas emission scenarios to project changes to the climate system and then identify potential impacts on communities. A limitation of this is that it excludes context-specific socio-economic, political, cultural, behavioral and ecological variables that are relevant for adaptation policy [13].

Adaptation policies need to be pragmatic, problem-oriented and participatory [14]. Previous studies have suggested that policy making based on rigorous scientific evidence (e.g., climate modeling) is not sufficient for guiding vulnerability reduction strategies because of the multidimensionality of climate impacts [15]. Furthermore, most studies that attempt to predict future climate challenges are limited in order to obtain precision, and are often not appropriate for adaptation-related decision-making 'on the ground' [16]. There is an increasingly urgent need for more holistic and contextualized understandings of livelihood vulnerability to meaningfully inform local decision-making [3]. This is particularly the case in developing areas, where people are largely dependent on climate-sensitive natural resources for their livelihoods [17,18]. Although a number of studies have been conducted in different parts of the world to characterize and assess vulnerability from different points of view, there has been little research that compares and combines these views [19]. Research is therefore needed to develop a conceptual and methodological approach that can more systematically identify the missing components of livelihood vulnerability, characterize and integrate them, and describe their policy implications to facilitate sustainable livelihood adaptation [20].

This paper offers such an analytical framework, drawing on livelihood vulnerability literature. In the following section, we describe the existing policy challenges associated with rural livelihood vulnerability. By articulating the Vulnerability Assessment Framework [21] and the Sustainable Rural Livelihoods Framework [22] into a shared framework, we present a stepwise and systematic approach for assessing context-specific livelihood vulnerability. In order to demonstrate how this adapted framework can be applied, and how it can contribute to better understanding of rural livelihood vulnerability to inform adaptation policies, we present a case study of the northeastern floodplain of Bangladesh, drawing on available scientific literature and policy documentation. The resulting analysis highlights how multiple interpretations of livelihood vulnerability can be integrated to help inform adaptation strategies and avoid maladaptive trajectories.

2. Rural Livelihoods and Climate Change Policy Challenges

We followed the definition of livelihoods used by the IPCC (p. 798), as: "... the ensemble or opportunity set of capabilities, assets, and activities that are required to make a living" [23]. Livelihoods in the rural areas of developing countries are often characterized by extreme poverty, social discrimination and a heavy dependence on natural resources [24]. In the presence of climate change-related stresses, natural resource-dependent and climate-sensitive livelihood activities can become particularly threatened [25]. This situation raises two key research and policy challenges: First, local resource use and distribution practices [26]; and, second, the degree of livelihood uncertainty due to climate variability [27]. Both of these broad challenges can be better understood when the

influences of climate on locally-specific socio-economic and social-ecological conditions are studied together [12]. However, knowledge concerning the diverse contexts within a particular country is likely to vary with political interests, highly visible climate impacts (e.g., extreme loss of life and property) and media coverage [28–30]. It has been argued that climate change and its stresses will both reduce a state's capacity to provide opportunities and services for affected people [31], and curtail rural communities' capability to respond to climate change impacts [32–34]. A lack of information and knowledge flows may further lead to an inequitable distribution of scarce resources leading to conflict and social insecurity [35]. This potential situation is particularly relevant in developing areas where knowledge and research infrastructures have yet to be sufficiently developed [36].

2.1. How Do We Understand Livelihood Vulnerability to Climate Change Impacts?

Livelihood vulnerability assessment generally views human and ecological systems as two inter-connected systems [21], and considers vulnerability to be the outcome of not only changing climate properties, but also of social, economic, institutional, political and technological processes [19]. Focusing on the capacity of a household to anticipate and adapt with climate change impacts, this approach assumes that insufficient asset accumulation (in the present) limits the capacity of a household to respond to future climate impacts [37–39].

Climate change brings uncertain and transformative changes to both social and natural resource systems, and its impacts are adversely felt when it limits a household's capacity to grow and develop [19]. Sen [40] and Devereux [41] posit that household vulnerability depends on the availability of assets to which a household has 'full rights'. Assets buffer risk, enhance recovery and, based on the level of possession, generate disproportionate outcomes for the households in a community [42]. Hence, questions related to climate vulnerability are strongly connected to locally-embedded poverty, economic inequality and institutional structures [43]. Poorer sections of a community are more prone to falling into poverty traps due to repeated climate stress events that limit their capacity to sustain livelihoods, thus making them the worst victims of climate change [44,45]. Notably, access and entitlement to assets are governed by institutional processes that extend beyond those of the national government and its legal frameworks; indeed, the distribution of assets is highly connected to social norms and locally-embedded political systems [46]. In a socially and economically unequal society, poorer people tend to have limited participation levels in both local and national institutional processes [47–49] because of their insufficient social networks and low political power [50]. Therefore, it is often argued that vulnerability reduction can be enhanced by securing social justice for, and the economic inclusion of, marginalized groups [26]. The human dimension of vulnerability stresses the importance of deliberative policy-making that values and facilitates public participation in the development of empirically guided adaptation strategies.

2.2. How Do We Understand Livelihood Sustainability in the Face of Climate Change Impacts?

Livelihood sustainability is essential for adequate stocks and flows of food, income, shelter and other necessities [51]. Chambers and Conway [52] and Ellis [27] have posited that rural livelihoods are environmentally sustainable when they maintain the assets on which they depend, and socially sustainable when they can cope with, and recover from, shocks. Livelihood sustainability can be better understood by characterizing livelihood assets, which include social, financial, human, manufactured and natural capitals—jointly known as the "capital assets" [22,27,51,53].

Putnam [54] (p. 35) defines social capital as "the features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions." Social capital engenders collective actions that organize people in order to provide them access to, and use of, institutional resources [55–57]. Bebbington [53] and Pretty [58] posit that different forms of social capital play a supportive role in gaining access to other assets and services (e.g., property rights, credit access, development incentives). For example, bonding (connecting community members with "strong ties"), bridging (connecting neighboring community members with dissimilar

situations through “weak ties”), and linking (connecting community members with power and financial resources through “vertical ties”) social capitals can promote self-governance with regards to common resources, knowledge and information sharing, and cross-scalar institutional, political and economic interactions [59–62].

Human capital refers to the qualitative and quantitative availability of labor, skills, knowledge and experiences [57,63,64]. Sen [65] suggests that this capital widens opportunities for individuals to participate in institutional and market mechanisms and enhances their capability to choose favorable livelihood options. Since investing in generating human capital helps individuals diversify their livelihood opportunities in non-natural and wage-earning activities, it can also help enhance their production possibilities and their capacity to cope with risks and uncertainties [66,67].

Saving and credit opportunities (or their substitutes) that can be directly invested into production activities are regarded as financial capital. This asset can also be invested for the purpose of securing other assets like natural and manufactured capitals [27,53,63]. For example, fishing communities in Bangladesh pay rental fees to the government in order to obtain wetland fishing rights [57]. In addition, buying water from community-based irrigation systems during the drought season is a common practice in Tanzanian indigenous peasant communities [68]. Rakodi [63] posits that, when invested in production inputs (e.g., buying improved seeds, fertilizers and pesticides for increasing agricultural productivity), financial capital can increase the productivity of other assets such as natural capital.

The equipment and infrastructure (e.g., roads, irrigation systems, embankments, etc.) used to maintain livelihood productivity are referred to as manufactured or physical capital [64]. This type of asset can be owned and developed both socially and privately. The IPCC [69] suggests that the poorest people in a society usually occupy marginal areas, which do not have adequate physical protection from climate change impacts. Hence, Rakodi [63] suggests that investments in manufactured capital (e.g., transportation network building, irrigation channel development, etc.) should be aimed at protecting the poor from marginalization and external stresses. However, such investments need to be adjusted with local biophysical and ecological properties [70]. In addition, the level of privately-owned manufactured capital may significantly contribute to economic inequality and social marginalization. For example, Heltberg and Tarp [71] have found that farming households in Mozambique who possess privately-owned manufactured capital (e.g., a motorcycle, radio, television, mobile phone) have wider market participation opportunities for selling their products, which in turn affords them an economically advantageous position in the community. In addition, Heltberg et al. [44] note that the loss of this capital due to climate change impacts (e.g., destruction of houses from floods or cyclones) may exacerbate asset inequality and lead to a “poverty trap”, as the poorer sections of society usually lose more than the richer sections, and recovering lost assets tends to be more difficult for them due to their generally high cost of repair and replacement.

According to Rakodi [63] (p. 316), natural capital is “made up of the natural resource stocks from which resource flows useful to livelihoods are derived, including land, water and other environmental resources.” Access to and ownership of natural resources is central to rural livelihood sustainability [64]. Babbington [53] suggests that households possessing high levels of natural capital have a marked advantage in terms of obtaining support from and influencing external agents (e.g., government institutions). Poorer households that do not own private natural resources (e.g., land, forest, fisheries) may rely on common or open access resources [63,72]. However, locally-embedded political processes, conflicts over resource use, and government policy may limit the ability of poorer households to access such resources [73]. Consequently, their insufficient capacity to cope with climate stresses, and the resultant loss of natural capital, may lead to recurrent vulnerability [74].

Chambers [75] and Rakodi [63] suggest that capital assets are connected to each other. However, rural households tend not to invest all their capital assets towards a single activity; instead, they often opt to distribute their assets in order to diversify their livelihood strategies through agricultural intensification (obtaining more output from a unit of land by investing more in production inputs), extensification (increasing land for cultivation) and migration to seek non-farming activities [22].

Rakodi [63] and Mphande [76] suggest that the selection of strategies depends on three conditions: (i) the internal structure of a household (e.g., the ratio of employed to unemployed household members, timely availability of usable workforce, inheritance of parental livelihood activities, etc.); (ii) the geographic locations of the households (e.g., households located in urban areas are more privileged than those in rural areas due to a greater availability of opportunities); and (iii) the household's connectivity to the wider market, as well as social and political systems (e.g., national political instability or agricultural market failures may reduce the availability of opportunities).

2.3. How Can We Comprehend Livelihood Sustainability in the Face of Climate Vulnerability?

The Vulnerability Assessment Framework developed by Turner et al. [21] considers vulnerability as being a function of context-specific exposure (intensity of climate stresses [23]), sensitivity (propensity of a system to be affected by the stresses [23]) and adaptive capacity (capacity to respond to the stresses and derive positive outcomes [23]). This framework can be applied across sectors following contextual modifications to ensure appropriate assessment variables (see, for example, Ford and Smit [77]; Ebi et al. [78]; Johnston and Williamson, [79]; Wilhelmi and Hayden [80]; Hughes et al. [81]; Prosperi et al. [82]). The SRL framework conceptualizes vulnerability as the external stresses that can affect livelihood assets, while assets can also generate feedback responses to the stresses [22]. Asset responses can be aided by external institutional and policy support (e.g., government, donor, non-government organizational supports) when needed for deriving favorable livelihood outcomes (e.g., increased income, agricultural productivity, health care system, food security, etc.) [27].

It is evident that both frameworks consider relationships between stresses and livelihood sustainability, with the variables included in the SRL framework (e.g., capital asset and livelihood activity variables) [25] particularly useful for understanding livelihood dynamics across scales (e.g., local to national) under climate change [22]. Building on the same conceptual foundation, Hahn et al. [25] developed the Livelihood Vulnerability Index to generate normative judgements regarding the level of vulnerability in different contexts, build general awareness regarding vulnerability in different contexts and to monitor adaptation policy performance [83]. While valuable, the index is limited in its ability to capture the internal and external dynamics of different asset variables in different contexts as the outcome is a composite of all assets. According to the SRL framework, understanding the dynamics of different asset variables is a prerequisite to strategize livelihood sustainability [22], and therefore is essential for adaptation decision-making. To help address this limitation, we present an integrated conceptual framework (see Figure 1) that includes five functional components (i.e., understanding and specifying context, exposure, sensitivity, adaptive capacity and institutional and policy responses). The analytical variables associated with the 'context specification' component have been derived from the Vulnerability Assessment framework (e.g., spatial and temporal scales, geographic space and sectors), while the analytical variables used for the remaining four components are derived from the SRL framework.

2.3.1. Understanding and Specifying Context

Since both vulnerability and livelihood sustainability are context-specific, there is a need to assess the interactions among temporal, spatial, social, economic, political and resource availability dimensions in order to characterize a particular context [19,20,84,85]. Climate change impacts will alter the biophysical properties of a context and, therefore, will also affect the interactions among different dimensions regulating the dynamics of climate vulnerability [19,86]. While it is important to understand how to determine a context, it is equally important to specify what context needs to be understood for adaptation policy-making at different levels (e.g., national, sub-national or municipal) [85]. For example, a country will be comprised of multiple socio-economic and biophysical contexts, and not all will be equally well understood, leading to policy and resource distribution biases [29]. Thus, a systematic synthesis of existing knowledge with an aim to answer what to study, where to study and how to study can be a useful approach for specifying and characterizing a context [12,87,88]. Once the context

is identified and characterized, the other components of the framework can be better explained using appropriately contextualized variables. For example, wetland resource system-based livelihood asset variables are likely to differ from those in agricultural resource systems.

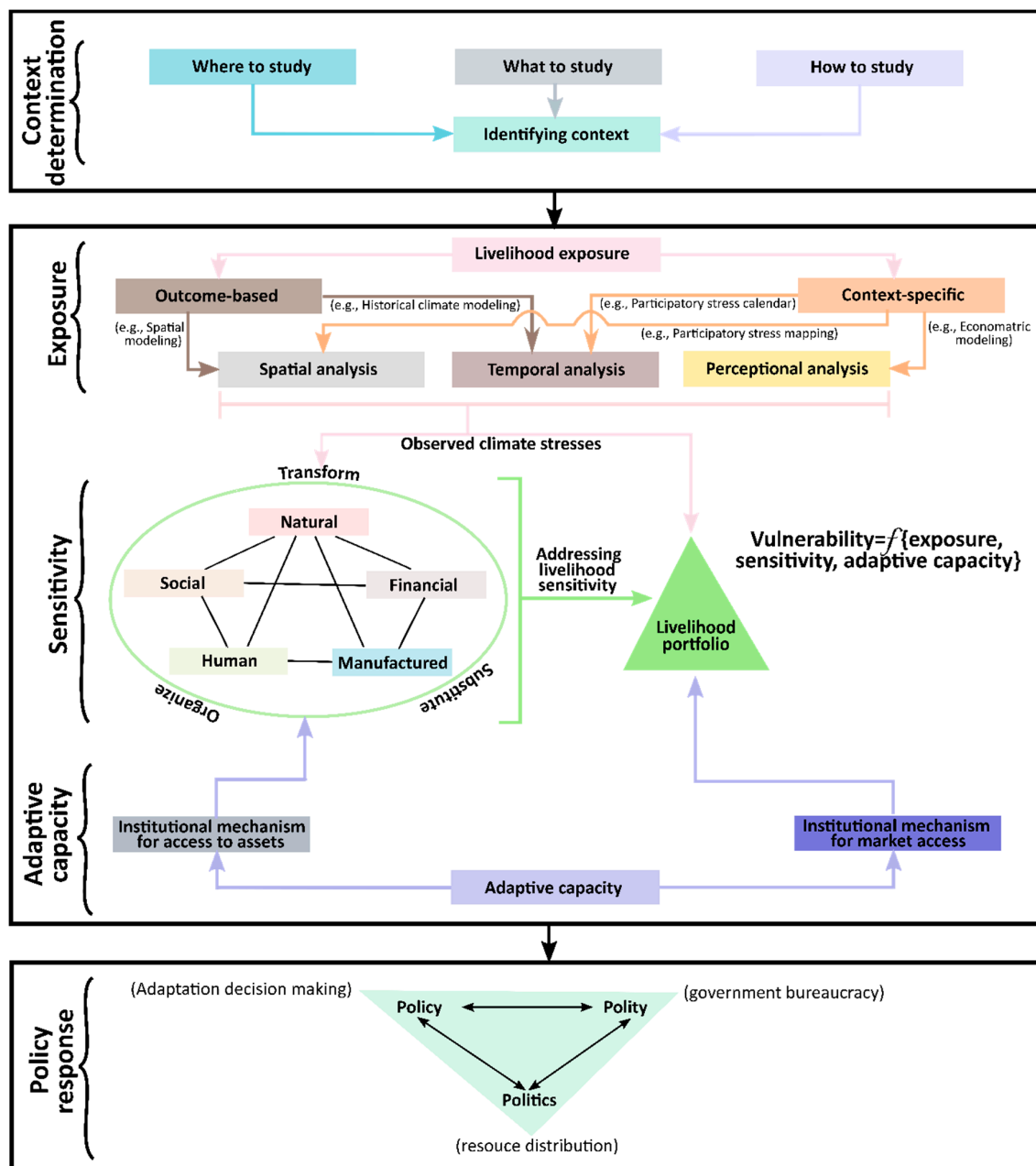


Figure 1. Framework for studying context-specific livelihood vulnerability and its cross-scalar integration. Note: The framework begins at the top, with identifying a context that needs to be studied along with specifying which aspects of livelihood vulnerability need to be understood and how they are to be studied. Once the context is identified, the exposure of the context to different climate stresses needs to be explained using both ‘outcome-based’ and ‘context-specific’ framings. This step leads to discerning the sensitivity of livelihood practices, taking account of the availability and uses of different capital assets for innovating and diversifying livelihood practices. The following step involves the assessment of adaptive capacity which involves the formal and informal institutional arrangement for determining the availability of, and access to, capital assets. The final step of the framework involves an analysis of adaptation policies to minimize context-specific vulnerability and to avoid maladaptive trajectories.

2.3.2. Exposure

IPCC defines exposure as the frequency, extent and nature of climatic extremes in a local setting [23]. Ribot [89] and Ford et al. [90,91] have posited that social phenomena along with climatic variability are responsible for exposure, which suggests that both social and ecological components are important. However, exposure is most frequently studied using climate variables (e.g., temperature trend, precipitation pattern, frequency of extreme events like drought, flood, cyclone etc.) that are used to observe potential present and future risks—identified as the ‘outcome-based approach’ of exposure assessment [19,92,93]. Engaging community perception-based assessment of stresses is also important [94] with experiential interpretation being key to ‘context-specific’ rural livelihood vulnerability assessment [19,95,96]. Such assessments can be influenced by local ecological properties, nature and use patterns of resources, observational and tacit knowledge of communities and the availability and seasonality of resources [97,98]. Further, many regional climate models based on long-term climate data fail to adequately account for local climate properties, and thus, insufficiently inform understandings of more locally-observed impacts [99,100]. Moreover, rural livelihood adaptation decisions are made based on the experiential and subjective interpretation of climate change impacts [101]. Importantly, exposure does not sufficiently indicate a system’s vulnerability to climate stresses. More specifically, a system, community, household or individual may be exposed but not vulnerable. A system can be said to be vulnerable only when it is exposed to stresses and reacts to them [23].

2.3.3. Sensitivity

Sensitivity is defined as the degree to which a system is affected, either positively or negatively, by climate stresses [5], and along with exposure, determines the extent of vulnerability. Thus, Smit and Wandel [33] and Ford et al. [90] identify exposure and sensitivity as two inextricably associated components of vulnerability; with this association explained as having “dose-response” interactions [2,21,102,103]. Smit and Wandel [33] characterize this dose-response association stating that it depends on interactions between system characteristics and climate stimuli. Further, Füssel and Klein [102] distribute climate stimuli and system characteristics (i.e., non-climatic factors) between exposure and sensitivity respectively. Characterizing access to, and use of, capital assets is considered key to understanding livelihood interactions with climate sensitivity [104]. The underlying notion of such analysis is that the assets generate livelihood opportunities and diversities [75,105,106]. However, the SRL framework also suggests that capital assets are organized, transformed and substituted in order to strategize livelihood portfolios [22,63], although this remains understudied in the livelihood vulnerability literature. Better understanding this property of capital assets is likely to be particularly important because asset organization ultimately determines feedback relationships with vulnerability, and may help with reducing negative livelihood sensitivity to climate impacts [64].

2.3.4. Adaptive Capacity

Adaptive capacity is the impetus that influences the ability of an individual, a household or a community to maintain their livelihoods in the face of climate stresses [33]. Engle [107] suggests that adaptive capacity modulates livelihood exposure and sensitivity to climate stress to help maintain and improve livelihood practices. Institutional and governance mechanisms that determine access to different capital assets are considered to be some of the most important determinants of adaptive capacity [108]. Institutions are the mutually agreed upon rules that specify who gets access to a resource system (e.g., fisheries, irrigation, forest, agricultural resources etc.) and what actions are permitted or not [109]. Institutions are developed both formally (as a coded form) and informally (as social norms and values) [109]. Both forms of institutions play pivotal roles in determining adaptive capacity. For example, formal institutions provide the rational and legitimate mean of transaction, and therefore, articulate the process of market integration within and across communities and scales (e.g., from a

local level market to broader scale markets operating at regional, national and international levels). Thus, formal institutions have considerable influence on livelihood portfolios. Informal institutions, on the other hand, are locally embedded and often based on ‘thick’ social networks. Informal institutions determine and reflect local level resource use politics, and emerge from local power structures, social systems, historical resource use practices, local knowledge systems, and the biophysical properties and resource stocks of a system. They therefore influence the distribution of resources and access to higher levels of market.

2.3.5. Policy Context

In the form of government policies, institutions also specify who is able to access government incentives for diversifying livelihood practices in support of adaptation. However, adaptation policy decisions need to be based on vulnerability and should aim to maximize the sustainability of desired adaptation practices [110]. It has been argued that both communities’ and governments’ responses to climate stresses may lead to ‘maladaptation’—the unintended consequences of adaptation actions [111], and may fail to appropriately serve the adaptation demands of an affected community. Such situations may occur as a consequence of weak adaptation options and insufficient foresight resulting from a number of factors like knowledge gaps, institutional and policy rigidity and under-coordination between policy and local contexts, many of which could be negotiated by institutional and policy innovation [112,113]. Adaptation actions created in a knowledge vacuum with weak institutional and policy systems may also serve to redistribute vulnerability from one sector to another or from one community to another [26]. Notably, government decision-making processes are an assembly of three institutional levels including: policy (decisions that are taken), polity (bureaucracy that bridge national decision-making and local demand) and politics (dynamics of decision-making) [114]. Hence, analysis of change should occur at each of these decision-making levels in order to help inform government adaptation strategies [37,89]. Since large-scale adaptation decisions are most often made at national levels, it is particularly important to assess how local understandings of vulnerability are translated into policy and what changes result from decision-making processes seeking to facilitate adaptation actions at local levels.

3. Case Study: Rural Livelihood Vulnerability in Bangladesh

Bangladesh is considered one of the most climate-affected countries on Earth [115], experiencing diverse climate stresses (e.g., floods, droughts, storms) with significant implications for its natural resource-dependent communities and households [116]. The nature and impact of these stresses vary across the country because of diverse geographic properties, resource abundances and resource management practices, and therefore, form an array of distinctive contexts. For example, soil salinity and massive oceanic storms are common in the southern and southeastern regions of Bangladesh [117], while drought and seasonal flooding are frequent in the northern and central regions [118–120] with the northeastern region particularly affected by flash floods, seasonal floods and drought [121]. Beyond the local geographic and resource use characteristics of climate impacts, resource management policies, strategies and institutional approaches also influence local levels of vulnerability and adaptation [2,122].

To characterize the nature of climate events and their influences on rural livelihoods, a number of studies related to climate vulnerability have been conducted in Bangladesh [123] resulting in diverse perceptions and policy interpretations [4,123,124]. Most previous research on climate vulnerability in Bangladesh have broadly sought to answer questions related to: (i) the present and future natures (e.g., duration, extent, frequency) and impacts of different climate stresses; (ii) the socio-economic factors that limit the capacity of affected populations to adapt to the stresses; and (iii) the policy interventions and their limitations for facilitating future interventions [87]. Drawing on meteorological perspectives [7,19], many studies have characterized the nature of climate stresses and estimated their impacts on different livelihood-related production sectors, including agriculture and fisheries [57,125–129]. At the same time, these studies have forecast future climate stress potentials at national and sub-national scales,

contributing significantly to national policy processes [130,131]. For example, Begum and Fleming [132] and Mirza [133] predicted that sea level rise and increasing river water discharge due to global warming will change and alter the natural flood properties in Bangladesh, and that this will influence agriculture and other rural economic activities. Later, it became clear that climatic events have been changing, with impacts shifting from one region to another [134]. As a consequence, many natural resource-dependent communities in rural Bangladesh have been experiencing new types of stress. Such studies have been primarily based on an outcome-based framing [19], particularly focused on how greenhouse gas emissions and the subsequent global warming will drive climatic vulnerability. However, as noted by Burton et al. [135] and Füssel and Klein [102], this approach generally fails to adequately detect the socio-economic dimension of vulnerability.

The socio-economic factors associated with climate vulnerability are known to be highly context-specific. The identification of contexts can be better facilitated by exploring questions related to who and what is vulnerable to what kind of climate stress [136,137]. Research into the socio-economic aspects of climate vulnerability in Bangladesh has been exploring how rural poverty, disproportionate distribution of livelihood resources and socially-embedded political marginalization are jointly enhancing vulnerability [37]. These studies reveal that climate impacts like water stagnancy and saline water intrusion are altering the land and resource qualities in Bangladesh, resulting in a dynamic change in rural livelihood practices [117]. Rural communities in Bangladesh, who historically depend on agricultural livelihoods, are diversifying their livelihood practices to reduce risks [138,139]. As a consequence, a widespread shift in land use practice, rural-urban migration and seeking employment in non-natural resource-dependent livelihood activities have been emerging [117,120,140]. However, it has also been observed that vulnerability has intensified as a consequence of widespread poverty, limited access to natural resources and insufficient institutional development at the local level [61,141–144]. In relation to rural livelihoods, resource distribution and access are particularly important because ownership of resources enhances the capacity of affected communities to take adaptive actions [89]. For example, Pouliotte et al. [117] observed that the land use decisions of small land owners in the southern coastal region of Bangladesh depended on the decisions of larger land owners, while many such decisions do not support the adaptation actions of the poorer households. As a result, these smaller landholders move to urban areas to shift their livelihood practices, losing control over land resources, and becoming potential victims of urban climate vulnerability [145].

Despite the increasing intensity of climate stresses, Bangladesh has been gradually mainstreaming climate-sensitive adaptation actions in its national development policy and programming [115]. Bangladesh was one of the pioneering countries to develop a National Adaptation Plan of Action (2005) [146], which was further revised and developed through the Bangladesh Climate Change Strategies and Action Plan (2009) [147]. These plans envisioned the need to identify adaptation deficits, and intended to locate potential sectors and regions where adaptation supports are necessary [115,148]. The broad aim of these plans was to enhance the capacity of affected communities by ensuring poverty eradication, sustainable livelihoods, efficient governance systems, infrastructural development and knowledge generation [44,147–149]. In order to ensure financial support for implementing the plans, the government established funding mechanisms supported by both the national government and international donor agencies [150]. Bangladesh's intention to combat climate-related impacts has also been well reflected in the National Sustainable Development Strategies and in other more recent development plans in almost all sectors [151]. Despite these advances, the national development and adaptation plans have been heavily criticized because of their generalized nature, insufficient contextualization and the inadequate and inefficient incorporation of affected communities' knowledge and viewpoints in the planning processes [152,153]. Further, there has been a general lack of adequate science and policy interaction in the policy and planning process leading to incongruences and significant knowledge gaps [154]. As a result, it is difficult to identify which sector and region needs priority research and data collection to inform adaptation policies [4,155].

3.1. Step 1: Identifying the Context Needing Vulnerability Assessment

Following the first step of the framework (Figure 1), the context requiring vulnerability assessment in Bangladesh needs to be determined. Based on a systematic review of peer-reviewed studies published between 1994 and 2017 (April) on climate change issues in Bangladesh, Rahman et al. [87] specified the northeastern floodplain as being the most understudied and least policy-focused region in the country. Biophysically, this resource-rich area accommodates some of the country's largest freshwater wetlands. It is also considered one of the most climate vulnerable parts of Bangladesh because of its geographic location, climatic properties and ecological nature [29,154]. The area is bordered by the mountainous territories of Assam and Meghalaya provinces of India and receives the highest rainfall in Bangladesh [131]. The area also falls under one of the most complex trans-boundary river systems in South Asia, known as the Barak river tributary [156]. A total of 23 trans-boundary rivers flow through the floodplain, and serve as the main ecological driver of the wetland dominated ecosystems. These wetlands are locally known as *haor*, which are enriched with natural resources and biodiversity [156]. According to the Bangladesh *Haor* and Wetlands Development Board [156], *haors* are the bowl-shaped depressions of considerable aerial extent lying between natural levees of rivers or high lands of the northeast region of Bangladesh. In most cases, *haors* have been formed as a result of peripheral faulting leading to depressions. During the monsoon period, most of the wetland areas are submerged, while water remains only in some permanent depressions in winter—known as *beels* [156]. These depressions serve as valuable habitat for fishes and other aquatic fauna, while agriculture is extensively practiced in dry areas. A large number of populations directly or indirectly depend on these *haors* for their primary livelihood activities like agriculture and fisheries [61].

Socio-economically, the wetland resource-dependent communities of this area are subjected to extreme poverty and economic marginalization [157]. In particular, economic inequality is very high in the area, dividing the resident communities into two contrasting economic groups [57]. This divide influences the political power differentials and reduces the poorer group's capacity to get access to the natural resources for livelihood activities [57,158]. Most of the population depends on agriculture for their primary livelihood, despite landlessness being a common feature [61]. Landless or extremely poor farmers depend on shared cropping systems [156]. Fisher groups are particularly marginalized in this region as government fisheries' resource management policy makes it difficult for them to obtain property rights (for more details, see Khan and Haque [158]; Rahman et al. [57]; Rahman et al. [61]; Hossain et al. [159]).

In the case of the northeastern floodplain region, it will therefore be important to understand what the common climate-related impacts in the wetland-dominated ecosystems are and how they affect wetland resource-dependent livelihood activities (Table 1). Due to the geographic location and known ecosystem properties, it is necessary to consider both the 'outcome-based' and 'context-specific' interpretation of vulnerability, while also incorporating how non-climatic variables are affecting vulnerability.

3.2. Step 2: Assessing Livelihood Exposure to Climate Impacts in the Northeastern Floodplain

The second step of the framework (Figure 1) involves an exposure analysis using both 'outcome-based' and 'context-specific' framings. Following the 'outcome-based' framing, the northeastern floodplain system experiences both flash floods and regular seasonal floods, with an increasing frequency, duration and extent of these stresses reducing agricultural and fisheries productivity [131]. Few studies have been conducted to illustrate the intensity of climate change impacts and their potential effects on the lives and livelihoods of the floodplain. For example, using time series analysis of temperature data, Nury et al. [160] estimate that yearly maximum and minimum temperatures are increasing at the rates of 0.03 °C and 0.026 °C respectively. This prediction is also supported by Nowreen et al. [131]. Using a regional climate model, Nowreen et al. [131] conclude that the highest significant rainfall and temperature variabilities are observed in pre-monsoon period when most of the flash floods occur. They also note that intense rainfall takes place in deeply flooded *haor* areas, which are mostly located in the central part of the

floodplain. In addition, Haque and Basak [161] study the land cover change of Tanguar *haor*—one of the major wetlands of the floodplain—revealing that deep water bodies (i.e., *beels*) are disappearing at a faster rate due to land use change like widespread housing and agricultural development. Thus, both climatic and non-climatic factors are jointly determining the exposure of the floodplain to climate change impacts (Table 1).

While these outcome-based studies provide a general overview of climate exposure in the area, more context-specific studies help to reveal how affected communities perceive the climate impacts (see also Figure 1). Using participatory research methods, Rahman et al. [162] and Jakaria and Islam [163] have evaluated community perceptions, revealing that despite the high exposure of the floodplain to climate change impacts, community members perceive an extreme climate event (e.g., regular season flood, flash flood, drought or extreme rainfall) as a stress to their livelihoods if it spatially and temporally co-occurs during their crop harvesting periods. Most of the climate stresses were intensified by the changing biophysical properties of the floodplain like the declining water discharge capacity of watersheds, increasing sediment loads and gradual decline of small canals and *beels*. However, going beyond the general considerations and assumptions of the climate models, community members also considered crop variety, seasonality, harvesting season and crop rotations when describing their livelihood exposure [162,164,165].

3.3. Step 3: Assessing Livelihood Sensitivity to Climate Impacts in the Northeastern Floodplain

The third step of our framework involves a sensitivity analysis of both the availability of, and access to, livelihood capital assets (see Figure 1). Sensitivity is linked with exposure and it is evident from the exposure research that multiple climate stresses affect the production activities in the northeastern floodplain area. Agriculture, being the most important economic and livelihood generating activity, is heavily affected by the stresses. For example, drawing on the account of affected community members, Jakaria and Islam [163] reported that every household loses 58 to 95% of their total agricultural production due to flash flood events and other climate stresses. Similar impacts have also been observed in fisheries, due to drought and gradual loss of watersheds and *beels* [162]. To buffer the loss, the community members innovate and implement several livelihood strategies using available capital assets, although the innovations are subjected to the availability of the assets [166].

Rahman et al. [166] have shown how affected communities in the area combine, transform or substitute one capital asset with the other to help diversify their livelihoods (see Figure 1). In so doing, three strategies are observed. First, the community members intensify their natural resource-based livelihood activities by enhancing crop diversity, cultivating high yielding crop varieties, planning short rotation crops in suitable places and by extensifying the activities by increasing the area of agricultural land, getting access to fisheries, collecting and selling edible wild foods and vegetables, duck and cattle rearing etc. [167]. The households, which have strong linking and bridging social capital and financial capacity, were found to adopt this strategy [61,166]. Second, some other community members who had the capacity to buffer climate change impacts, but do not possess adequate resources to minimize future risk, were able to maintain their status quo livelihood activities. This strategy may involve both natural and non-natural resource-dependent activities, where losses resulting from climate impacts on natural resource-based activities are minimized by non-natural resource-based activities [166]. Third, community members with high-linking social, financial and human capital were found to diversify their livelihood activities, mostly through non-natural resource-dependent activities. In so doing, the community members were converting one capital to gain access to another (Table 1). For example, some of the community members sell their land resources to cover the cost of going abroad or relocating to urban areas in order to find better-paying jobs. In some other instances, these activities are seasonal, meaning that the community members migrate to urban areas, particularly during the monsoon period, when there are less jobs available, and then return to the area for the cropping period. This strategy was found to be most common for people with lower education levels, technical training and skill along with little or no access to natural resources [166].

Table 1. Applying the framework to livelihood systems in the northeastern floodplain of Bangladesh.

Steps	Key Questions	Outcomes
Step 1: Understanding and specifying the context needing vulnerability assessment	- What is to be studied? - Where does it need to be studied? - How does it need to be studied?	- Need to understand the climate-related impacts on the wetland-dominated ecosystems of the northeastern floodplain. - The climate change impacts on the local livelihood activities in the area need to be understood. - The northeastern floodplain of the country is the most understudied and least policy-focused region in the country. - Both ‘context-specific’ and ‘outcome-based’ approaches need to be used.
Step 2: Assessing livelihood exposure	Outcome-based framing: - What are the types of climate- induced extreme events? - What are their trends, patterns, frequency and extent? - What is exposed to these extreme events? Context-specific framing: - How do affected people perceive climate impacts? - What is their knowledge and experience?	Outcome-based framing: - Flash floods and regular seasonal floods are the two most common climate extremes in the study area. - The frequency, duration and extent of these events are increasing. - Both agriculture and fisheries—the two main natural resource-based livelihood activities in the area—are exposed to these events. Context-specific framing: - Despite the high exposure of the floodplain to climate change impacts, community members perceive an extreme climate event as a stress to their livelihoods if it spatially and temporally co-occurs during their crop harvesting periods. - Most of the climate stresses were intensified by the changing biophysical properties of the floodplain, like the declining water discharge capacity of watersheds, increasing sediment loads and gradual decline of small canals and deep waterbodies.
Step 3: Assessing livelihood sensitivity	- To what extent are the livelihoods affected by extreme climate events? - How do the affected households organize, transform and substitute livelihood capital assets?	- Households lose 58 to 95% of their total agricultural production due to flash flood events and other climate stresses. Similar impacts have also been observed in fisheries, due to drought and gradual loss of watersheds and <i>beels</i>. - Community members intensify and extensify their natural resource-based livelihood activities by changing their cropping practices and diversifying alternative natural resource use practices respectively. - Community members who have the capacity to buffer climate change impacts, but do not possess adequate resources to minimize future risk, are able to maintain their status quo livelihood activities by building a livelihood portfolio of both natural and non-natural resource-dependent activities. - Community members with high-linking social, financial and human capital diversify their livelihood activities, mostly through non-natural resource- dependent activities.

Table 1. Cont.

Steps	Key Questions	Outcomes
Step 4: Assessing adaptive capacity	- What are the institutional and governance mechanisms that determine access to different capital assets? - How is the process of market integration articulated within and across communities and scales? - How do informal institutions affect local resource access and distribution?	- Both formal and informal institutional arrangements are determining access to capital assets, particularly financial and natural capitals. - Private and communal property rights are formally given to community members based on resource types and seasonality. - Community members in the region develop their informal and network-based collective organizations to obtain government support and subsidies. - Collective organizations tend to be led and developed by relatively richer and well-networked farmers who can dominate the collective decision-making process for their own benefit.
Step 5: Assessing policy responses to minimize livelihood vulnerability	- How are local understandings of vulnerability translated into policy? - What changes result from decision-making processes seeking to facilitate adaptation actions at local levels? - What actions are taken to avoid ‘maladaptive’ outcomes?	- Livelihood plans and policies claim to be developed using participatory approaches. - National-level policies and plans aim to address adaptation using more generalized approaches with some specific interventions designed specifically for the area. Regional policies and plans take the detailed context-specific properties of the floodplain into greater account. - Flash flooding protection strategies are highly reliant on physical infrastructure, which are detrimental to the ecological and economic properties of wetlands. Some actions depend heavily on external inputs, leaving community members in regular need of external support.

3.4. Step 4: Assessing Adaptive Capacity to Address Climate Change Impacts in the Northeastern Floodplain

For the fourth step in the framework, access to different capital assets is understood as depending on both the formal and informal institutions operating in the study area, and will therefore determine the ability of the communities to adapt in response to climate change impacts. In particular, property rights to natural resources and participation, and representation in social networks, have been found to determine the levels of capital assets owned by a household or individual [61]. For example, agricultural land ownership in the study area can be permanent or seasonal. In the case of permanent ownership, land can be used as collateral to gain access to formal loans from banks and other financial institutions (see also Figure 1). Seasonal ownership often involves shared cropping systems where the formal landowners allow farmers (also known as sharecroppers) to cultivate their land in exchange of a certain share of production [166]. In these situations, land cannot be used as collateral, with sharecroppers therefore dependent on an informal money lending system to gain access to financial capital, often at a very high interest rate. In many bilateral sharecropping arrangements, the farmers also need to carry the larger portion of loss resulting from climate-induced crop failures.

In addition to securing property rights to land resources, farming community members in the region also develop their informal and network-based collective organizations to obtain government supports and subsidies to maintain their agricultural activities [164]. However, as suggested in the framework, the local network-based informal institutions are heavily influenced by local resource use politics and power structures. For example, the government of Bangladesh provides irrigation and other farming technologies at a subsidized rate to the community members through a process that requires farmers to form collectives. However, these collective organizations are commonly led and developed by relatively richer and well-networked farmers who tend to dominate the collective decision-making process for their own benefits (Table 1) [166]. Thus, poorer farmers can become underrepresented and sometimes, their views are compromised. Additionally, some of these collectives function as micro-saving and micro-credit organizations, allowing members to access lower interest loans when required, and also offering loans to community members under certain conditions. However, due to their limited capacity, the effectiveness of these organizations in supporting sustainable livelihoods is questionable.

In a similar vein, access to fishery resources in the area can be through either open access rights or common property rights. According to the wetland management policy of Bangladesh, access to fisheries varies seasonally, with the open access rights allowing community members to fish across the wetlands in the rainy season, then only in open waters like watersheds (e.g., rivers and canals) during the winter and dry seasons. In contrast, the common property right allows fishing only in the dry season when water is retained in deep and permanent ditches, also known as *beels*. These *beels* are highly productive dry season fish habitats, which are usually distributed among local fishery cooperatives in exchange for rental fees paid every three years. However, the fishery cooperatives are often dominated by local elites and money lenders who usually accommodate the financial and political resources required to obtain the property correctly. All of these processes are maintained by informally developed institutions, which also demonstrates the local level politics and marginalization of less empowered community members [57,61].

3.5. Step 5: Assessing Policy Responses to Minimize Livelihood Vulnerability to Climate Change Impacts

The final step in the assessment focuses on evaluating gaps between context-specific vulnerability and institutional and policy responses to avoid maladaptive trajectories. The government of Bangladesh has responded to the livelihood vulnerability of the northeastern floodplain through both regional- and national-level climate adaptation and wetland resource management policies (Figure 1). While national-level policies and plans (e.g., Flood Action Plan (FAP), 1990; National Adaptation Plan for Action (NAPA), 2005; Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009; and National Plan for Disaster Management (NPDM), 2010) aim to address adaptation using more generalized approaches with some specific interventions designed specifically for the area, regional policies and plans (e.g.,

Master Plan for *Haor* Areas (MPHA), 2012) take the detailed and context-specific properties of the floodplain into greater account [164]. Notably, both broad groups of policies and plans claim to have been developed following a participatory planning process, although how public representation has been ensured remains disputed [168].

Rahman et al. [164] assessed the long-term effectiveness of the various plans relevant to adaptation in the region, noting that earlier plans (e.g., FAP, NAPA) were more sector-specific, top-down and were concentrated mostly on the economic aspects of adaptation, while more recent policies (e.g., BCCSAP, MPHA, NADP) took better account of the social and environmental dimensions of climate adaptation. In addition, more recent plans were supported by locally available resources and better coordination among different government agencies, forming a network of bureaucratic polity to facilitate the successful implementation of the plans [169] (see Figure 1). Despite these advances, many of the projects launched under the more recent plans have the potential to be ‘maladaptive’, resulting in negative consequences for the objectives of adaptation [165]. In particular, flash flooding protection strategies are still highly reliant on physical infrastructure (e.g., embankments) across the wetlands of the northeastern floodplain. Such ‘hard’ infrastructure can be detrimental to the ecological and economic properties of wetlands [165]. In addition, some projects depend heavily on external inputs (e.g., credit, training, materials, etc.), leaving community members in regular need of external support (Table 1). Alternative strategies for local livelihood adaptation could have better utilized the existing capacities of community members to respond to climate change impacts by, for example, addressing tenure insecurity issues, coordinating scientific and local knowledge, and working to reduce inequality in power distribution [57,165,170] (Figure 1).

4. Contribution of the Framework to Adaptation Policy

The application of the framework in the case study area helped to discern that despite the government’s growing capacity to plan for adaptation actions, many of the resulting actions may not work well with local resource management politics, potentially excluding the poorer and less empowered segments of the community. In addition, the analysis revealed that the effectiveness of the adaptation policies and plans depends heavily on the modification of the formal natural resource management policies, an area often overlooked in climate change adaptation policy.

4.1. Policy Responses to Minimize Livelihood Vulnerability to Climate Change Impacts

Many developing countries have centralized and hierarchical systems of policy-making that are prone to the problems of generalization and limited information leading to more linear and outcome-based interpretations of vulnerability [171,172]. In contrast, contextual vulnerability tends to be more locally connected, decentralized, and dependent on both local and expert knowledge systems [19]. Nevertheless, the importance of outcome-based approaches—which are generally founded on “scientific framing”—cannot be ignored, despite the relative advantages of more contextual approaches to help address the root causes of vulnerability (e.g., poverty, power differentials, political and cultural choices) [19]. Many studies have shown that outcome-based adaptation actions, such as embankment building, irrigation schemes and housing improvements, can help reduce livelihood vulnerability [173–175]. Again, climate impacts on rural livelihoods vary within and between societies, and many of these impacts cannot be immediately responded to without, at least, a case-based generalization [3,92]. Thus, an important question to ask is: Which of these outcome-based and context-specific interpretations of vulnerability will most effectively contribute to the formation of adaptation-related policies and practices? Here, O’Brien et al. [19] argued that the political and scientific differences between the two approaches are too great to overcome and instead, suggested a parallel and co-existing comprehension of both.

Our framework extends this discussion by postulating that other potential answers may be rooted in the scale of problem generalization and the congruence of interpretation between the two approaches. For example, Rahman et al. [87] note that the outcome-based questions asked in

national-scale studies are more related to understanding how different stresses directly impact different sectors (e.g., agriculture, fisheries, health). However, they also highlight that similar stresses produce significantly different outcomes for different locations, which is a phenomenon that is not directly accounted for by national-level vulnerability assessments. Therefore, it is necessary to go beyond single scale vulnerability assessments (e.g., national or sub-national or local), and to apply both context-specific and outcome-based approaches across scales (e.g., national and sub-national and local).

Participatory policy-making processes are often considered to be a useful way to incorporate multiple opinions and perspectives into a single scheme [176] and decentralize power and authority in order to establish more democratic policy options [168,177]. The National Adaptation Program for Action (NAPA)—which is a process that enables the Least Developed Countries to identify priority adaptation activities—drew upon the participatory policy-making approach in order to facilitate greater levels of locally-connected policies [168]. The Bangladesh government has made considerable progress in advancing public participation opportunities in adaptation-related policy and planning processes [164]. However, certain questions remain unanswered; for example, who is able to participate, and how is their participation managed? Ayres [178] provides a detailed description of public participation-related politics in adaptation planning in Bangladesh, stating that policy participants may have diverse understandings of vulnerability, and that the decisions made in this competitive environment may be influenced by power differentials among the participants. As a result, both context-specific and outcome-based views need to be considered in order to minimize the potential impact of power differentials.

Synthesizing climate forecast studies in northeastern Bangladesh, Rahman et al. [87] identify the future potential for repeated flash flood events, which was also reflected in the community stress perception study conducted in the same study area [162]. Importantly, the outcomes of both perception-based and forecast-based studies were generally better reflected by the more context-specific adaptation plan (e.g., MPHA) than they were by the national-level plans (e.g., NAPA and BCCSAP) [164].

4.2. Understanding Livelihood Vulnerability for Local Adaptation-Related Policy-Making

Frank et al. [179] and Saleh Safi et al. [180] posited that community perceptions are not only motivated by information about any particular stress, rather, they are also motivated by community members' direct experience of stress events. Community members tend to interpret information based on the intensity of the stress, their subjective experience, their memories surrounding those experiences and their capacity to respond [179,181]. Measuring a household's response capacity is a highly complex task due to its inter-relationship with environmental, geographic, social, demographic, economic and political factors [179]. In the case of rural livelihood vulnerability, Sánchez-Cortés and Chavero [182] and Bele et al. [96] linked stress perceptions to livelihood practices, cropping patterns, seasonality and cultural practices. Taking account of both the climatic (e.g., the frequency, extent and duration of stresses) and non-climatic factors (e.g., social, cultural, economic, geographic), the exposure analysis of the northeastern floodplain of Bangladesh indicates that non-climatic factors play a highly important role in constructing community stress perceptions. A community's long-standing experience with seasonal stresses allows it to specifically identify which extreme climate events are potential livelihood stressors and which are not.

Having both the SRL and vulnerability assessment concepts included in the framework allows the multidimensional nature of climate impacts to be better captured—commonly referred to as “multiple stressor” [183,184]. Tucker et al. [184] and Wachinger et al. [181] build upon the concept of multiple stressor, suggesting that external factors like product price uncertainty are stronger drivers of adaptive responses than the stress perceptions of community members. Thus, this framework can help to identify the non-climatic stimuli that intensify vulnerability, and, therefore, influence the selection of adaptive responses. For example, the exposure analysis in the case study highlighted that local environmental degradation, cropping and land use practices are some of the stronger non-climatic stimuli that construct the vulnerability of the area, turning a general climate event into a stress [162].

Participatory research based on local knowledge and community perception can help to identify these latent stimuli.

4.3. Context Specificity for Avoiding a Maladaptive Trajectory

Juhola et al. [112] note that maladaptation is the result of unintended consequences of adaptation actions that may shift vulnerability from one sector, community or system to another. Barnett and O'Neill [111] identify five types of maladaptation that can arise as a consequence of sector-specific adaptation actions: (i) increased greenhouse gas emissions; (ii) disproportionate burdens placed upon the most vulnerable populations; (iii) high opportunity costs; (iv) reduced incentive to adapt; and (v) path dependency. The case analysis of policy responses shows that many of the adaptation actions included in Bangladesh's national-level plans may be construed as comprising a maladaptive trajectory, with at least four of the five above-identified maladaptive actions being present in the current adaptation practices being employed in the studied areas.

Sensitivity minimization strategies and policy responses both identify that a number of interventions have been undertaken in the flood-prone northeastern part of Bangladesh. In particular, the policy responses note that some of these interventions are likely deleterious (e.g., embankment building, promotion of fertilizer- and pesticide-intensive high-yielding rice varieties) to the natural ecosystem [165]. Moreover, existing fisheries management policies can make it difficult for resource-dependent communities to obtain fishing rights, which limits the community's adaptive capacity to diversify livelihoods [166]. Thus, successful adaptive capacity enhancement strategies and adaptation plans should include the revision of other resource management policies upon which livelihood diversification largely depends.

In addition, the sensitivity reduction strategies demonstrate that, since climate stresses are common and obvious within the study area, local communities are adapting by expanding their non-natural resource-dependent livelihood activities. However, most of these interventions are hindered by a lack of human, social and financial capital. While adaptation actions should be designed based on local resource availability as well as local socio-political and socio-economic structures, government-designed adaptation strategies have the potential to increase opportunity costs due to a disconnect with locally available resources and innovations.

The adaptation actions included in the NAPA and the BCCSAP are extensions of sector-specific development interventions; thus, they are isolated in nature, which impedes the conditions necessary for their successful execution. For example, the analysis of adaptive capacity in the study area shows that power asymmetries, socio-economic disparities, and the inefficiency of local government serve to undermine adaptation interventions and often create opportunities for the community's rich and elite to obtain government support (e.g., elite control of the technological supports provided by government). Consequently, the poorer sections of society are generally left behind, resulting in a situation that traps them in poverty. There is, therefore, a need for interventions that can create inclusive and participatory adaptation and resource governance systems, particularly at local levels in the study area.

Finally, the impacts of path-dependent adaptation actions, such as embankment and irrigation system construction, are still considered as one of the main measures for protection against flood and drought. Although engineered infrastructure has been successful in solving immediate problems, Barnett and O'Neill [111] have suggested that such interventions actually decrease the ability of adaptation actions to respond to unforeseen changes in economic, social, environmental and climate properties.

5. Conclusions

Distributed in five analytical stages, our combined SRL and Vulnerability Assessment framework starts with identifying and characterizing a context that may require research and policy attention. An accurate identification of the context, specifying what, where and how to study livelihood vulnerability, is particularly important for developing areas where climate vulnerability and adaptation-related knowledge infrastructure is limited. Once the context is identified, the framework

moves on to explore the exposure of livelihoods within a community, using both context-specific and outcome-based framings based on scientific research. The assimilation of both interpretations is necessary to understand how affected community members are conceptualizing climate stresses and what adaptation actions they undertake based on their comprehension. In addition, community perceptions can identify and address scientific knowledge gaps. Building on this understanding of climate change impacts, community members will strategize the use of their capital assets to reduce their sensitivity. This process may lead them to organize, substitute or transform their assets in novel and strategic ways to innovate and diversify their livelihood practices. However, a community's access to, and the availability of, capital assets will depend heavily upon the formal and informal institutions affecting resource use. While formal institutions will often govern the access to natural resources, informal institutions will determine the network-based interactions and power distributions that determine the distribution of assets among the communities. It is worth noting that the properties of each vulnerability assessment component are context-specific and therefore need to be understood using variables that can characterize the capital assets possessed by communities. As a result, adaptation policy needs to be participatory, well-coordinated and long-term to enhance local innovation and facilitate the equitable distribution of capital assets in order to avoid maladaptive trajectories.

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