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Climate Change Challenge (3C) and Social-Economic-Ecological Interface-Building

Exploring Potential Adaptation Strategies for Bio-resource Conservation and Livelihood Development

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Climate Change Challenge (3C) and Social-Economic-Ecological Interface-Building—Exploring Potential Adaptation Strategies for Bio-resource Conservation and Livelihood Development: Epilogue

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Climate change is arguably the single most dominant environmental threat facing humanity. Its manifestations, particularly through rising temperatures, changing rainfall, sea-level rise and increasing droughts and floods have the potential to adversely impact natural ecosystems (such as forests, grasslands, rivers and oceans) and socioeconomic systems (such as food production, fisheries and coastal settlements). This is adding additional stresses to the ecosystem services, which form a substantial source of income to the rural inhabitants. It is most proximate and inextricably linked to well-being, development and economic growth which are part of the eight Millennium Development Goals (MDGs), which ran from 2000 to 2015. Addressing climate change requires policy formulation, research, technology transfer and diffusion, financing and enhancing adaptive capacity of the poor at national, regional as well as

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local levels. As identified by the UNFCCC, the people whose lives are most threatened by climate change are vulnerable groups particularly in developing countries, whose livelihood is traditional crop husbandry or livestock rearing. Therefore, mitigating climate change is an ethical concern. The chapters by Meenakshi Rajeev et al., Arun B. Chandran and Anushri, Letha Devi et al., Sreenivasaiah, K. (Chaps. 14, 23, 26, 32) addressed this issue through agricultural development. According to the report of the Intergovernmental Panel on Climate Change (IPCC 2014), India's agricultural sector would be one of the worst hit of any country in the world. With an erratic and extreme monsoon, the report states that by 2030 India would face an agricultural loss of over US $7 billion, affecting income of 10 % of the people (Neeshad online). But if climate resilience measures in the form adaptive strategies are implemented, 80 % of the losses could be averted, the report adds. In India, several Missions and strategies (Green India Mission, REDD+ etc.) have been implemented at various levels under International initiatives. It is crucial to look at the need of those initiatives and mould responses accordingly to satisfy the requirement for climate change adaptation and sustainable development at local level. UNFCCC has also given strategies on the development of national adaptation and programmes and the support by regional centres; which endows a platform for a bottom-up approach to confer and adapt with climate change impacts at regional level. Pandit chapter (Chap. 10) explores the question how humanity might find the solutions to these global problems. Strengthening livelihoods, developing sustainable land use policy, etc., have been increasingly seen as a critical strategy for supporting adaptation. The chapters by Bill Pritchard, Muhammad Haroon et al., Swamy and Nagaraju, Raju et al., Barun Deb Pal (Chaps. 2, 4, 5, 11, 13) looked at various facets of livelihood sustainability which will help the adaptation of the stakeholders to the possible impacts of climate change. In the recent COP 21 held in Paris, India committed towards creating an additional carbon sink of 2.5–3.0 billion tonnes of CO_2 equivalent through additional forest and tree cover (an increase of about 680–817 million tonnes of carbon stock) by 2030, for which 5 million hectares will be brought under forest cover. This will enhance carbon sequestration by about 100 million tonnes CO_2 equivalent annually (MoEF&CC). However, the Green India Mission is expected to deliver 50–60 % of this target, and therefore, there is a need for developing the plans and strategies to achieve the remaining goals along with introducing other instruments in for example creating climate resilient systems, adopting good practices, developing the strategies for emission reductions and financial provision etc. Therefore, there is a need to focus equally on adaptation as well as on mitigation to cope up with the impact of climate change across ecological regions of country.

1 Holistic Outlook: Integrated Approach

Anthropogenic changes in land use and land cover are global phenomena which are having intensifying consequences on food production, forest and water resources, in addition to climate change. Understanding the future vulnerability, exposure and responses required for interlinked human and natural systems is critical and

complex. But the challenge is to integrate huge number of parameters interacting in and among social, economic, and cultural sub-systems, which are not included holistically in most of analyses. Hence, appropriate methods and tools along with field-based case studies on human and biophysical environment with the intervention of climate change would provide better understanding of how paths are altered and how goals relating to sustainability under a changing climate can be achieved. As evidenced by the chapters by Anu Susan Sam et al. (Chap. 25), Himani Prakash (Chap. 21), Parmod Kumar (Chap. 30), P.S. Swain et al. (Chap. 6), Koppad and Tikhile (Chap. 27), Lakshmi and Indumathi (Chap. 33), Nautiyal and Schaldach (Chap. 34) and Gawan and Sen (Chap. 18) transdisciplinary and interdisciplinary approaches are in the forefront of this need.

The development of better land use policy (such as land use development at regional, state or national level) depends on the perceived risks of uncertainties due to variety of factors—such as climate change, socioeconomic, ecological cultural characteristics of the regions involved, and questions relating to technical feasibility and policy measures (Klabbers et al. 1996). For effective implementation, the scientific and technological research should support the policy-making processes. When science and policy differ then outcomes in the form of policy communication is often problematic. The chapter by Sunil K Agarwal (Chap. 35) addresses this issue of science policy and solutions. The research on land use and climate modelling (ex-post; ex-ante) will aid in making effective science-policy recommendations for climate change, and land use development (i.e. impact, causes, effects, adaptation and mitigation) at various spatial scales, all of which will further will help to support better policy formulations and galvanize institutional innovations. What is required is that scientific information should meet the requirements of policy demand and should be easily accessible to policy makers and decision takers. The integrated modelling approach strongly supports this viewpoint (chapter by Nautiyal and Schaldach (Chap. 34) and Schaldach et al. 2010; Nautiyal et al. 2010, 2013). On the other hand, policy makers and decision takers should formulate requisite information such a way that is easily understandable for researchers to provide available scientific information in their deliberations (van den Hove 2007). Landscape modelling helps to construct frameworks and to organize ideas and data to understand the complex human-ecological system and specially the spatial dynamics and processes over different temporal scales. Scenarios used in modelling involve a hypothetical sequence of future events that consider the fundamental uncertainties of the future. The research endeavours should focus on developing recommendations for micro levels depicting various geo-climatic regions in country as evidenced by the chapters by Saikia et al. (Chap. 8) Ankita Mitra et al. (Chap. 20) Kataktalware et al. (Chap. 31) Chand and Garita (Chap. 15) Kumar et al. (Chap. 24). There is a need not only for developing strategies at regional or national level (which is largely a top-down approach) but more importantly, to develop a bottom-up approach to address climate change, sustainable land use and linked socio-ecological development. Integrated approach should be encouraged to aim at adopting a bottom-up approach for sustainable land use development, climate mitigation and adaptation strategies. The need for pilot studies of mitigation and adaptation projects in various agro-climatic regions is addressed in the chapter by Nautiyal et al. (Chap. 36).

2 Need of a Proactive Response to Climate Change and Associated Bioresources Conservation

The response to climate change does not relate to the confines of the environment alone, but has multiple constituencies. Therefore, climate change assessment has to be done in viewpoint of impact, vulnerability and adaptation in different agro-ecological regions. As the scholarly fraternity are making efforts at global, nation, state and even at local levels to address climate change in the post 2015 agenda through mitigation and adaptation strategies, the information/knowledge base about ecosystem/land use modelling requires enhancement, especially in India. The chapters by Saikia et al. (Chap. 8), Khuda Bakhsh et al. (Chap. 12), P.J. Dilip Kumar (Chap. 3), Mansi and Jamwal (Chap. 28), Suresh Nadagoudar (Chap. 9), Kala S Sridhar (Chap. 16) address the bio-resource conservation and sustainable livelihood development under a changing climate and further providing connections with land use land cover policy making.

3 Climate Change and Food Security—The Global and Indian Contexts

Bill Pritchard and Muhammad Haroon et al. (Chaps. 2 and 4) addressed the food security of India and Pakistan under climate change scenarios. There is incontrovertible evidence that global temperatures have increased during the past century, and that the role of humans (anthropogenic forcing) is centrally implicated in this. The study of climate change is extensive in nature, looking at each component individually and then as a complete unit. It involves specialists from across the natural and social sciences. In recent years, considerable attention has been given to the implications of climate change for global food security. The Fifth Assessment Report of the International Panel on Climate Change (IPCC), released in 2014, concluded that global food security would be dramatically affected by climate change. In accordance with FAO definitions, the IPCC considers food security to include four dimensions—food availability, food accessibility, food utilization and food systems stability. Also, it needs to be taken into account that the food system by itself is a major contributor of greenhouse gases, and hence, reforming the global food system needs to be a major plank of climate change mitigation. The impact of climate change on food security will be felt at global, national and local scales. Vulnerable people and communities are at the frontline of these threats, and India faces major impacts including potential changes to the timing and strength of monsoons, retreat of Himalayan glaciers and sea-level rise. India is also vulnerable to the way climate change may affect neighbouring countries. Bangladesh is widely recognised as one the world' s most vulnerable nations to climate change, and climate migrants/refugees may seek to relocate to India, which may aggravate geopolitical tensions. The aim is to enhance our information base about the threats,

and adaptive potential, facing India. These adaptive actions can include enhanced food system supply and management via improved agricultural practices (both horticulture and livestock) and changed livelihood arrangements.

4 Climate Change and Vulnerability

The vulnerability of human populations and natural systems to climate change differs substantially across regions and across populations within regions (He et al. 2006; Torresan et al. 2008). Climate stress in particular can compromise the ability of the different branches of the ecosystem to sustain productivity that influences livelihood of the local people (Archer et al. 2007; Nautiyal and Kaechele 2008). Such a situation is particularly concerning in the light of projected increasing climate stress under future climate change due to, for example, increased frequency of extreme precipitation events (IPCC 2001, 2007; Nautiyal et al. 2013). The natural and social systems of different regions have varied characteristics, resources and institutions, and are subject to varied pressures that give rise to differences in sensitivity and adaptive capacity (Torresan et al. 2008). From these differences emerge different key concerns for each of the conditions in regional level in different parts of the world. Within regions, however, impacts, adaptive capacity and vulnerability will vary and that depicts the particular local environment (Olsson et al. 2004). Therefore, the impact level varies at macro and micro level. In emerging economies like India, where economic and institutional circumstances are less favourable, socioeconomic systems are much vulnerable to climate change and such vulnerability is highest where adaptability is much less than the sensitivity (Wainger et al. 2004). From an Indian perspective, the Himalayan region, the east coast and west coast are highly sensitive to climate change, though in different ways. However, adaptive capacities are comparatively weak. Threatened Himalayan and coastal environmental systems are exposed to range of hazards connected to climate change (i.e., receding of glaciers, sea-level rise, increased level of inundation and storm flooding, decrease in rainy days and high rain fall intensity) that may further lead to landscape degradation and consequently appears in a suite of socioecological impacts (such as loss of habitation, soil loss, loss of tourism, decline in productivity of the system and migration) (Saxena et al. 2001, 2005; Ives and Messerli 1989; Olsson et al. 2004; Torresan et al. 2008; Wills et al. 2008). Olmos (2001) stated that in developing countries adapting to climate change is an urgent issue as the poor are expected to disproportionately suffer the impacts of climate change so developing countries should be focus on vulnerability and adaptation programmes. The chapters by M. Srinivasa Rao et al. (Chap. 19), Barun Deb Pal (Chap. 13), Arun Kumar et al. (Chap. 22), Mansi et al. (Chap. 29) Kala S. Sridhar (Chap. 16), Arun B. Chandran and Anushree (Chap. 23) C.M. Lakshmana (Chap. 7) address the issues of climate change and livelihood supporting activities. Agriculture which currently accounts for 24 % of world output uses only 40 % of land area (FAO) and is highly dependent on the climate.

Human dependence on agricultural livelihoods, particularly by the poor, is high and so land use/land cover change needs much attention to monitor the impact of climate change in developing countries. It is therefore, required that responses to climate change can either seek to be reduced the level or rate of change (*mitigation*) or need to manage its consequences (*adaptation*) (Halsnaes and Verhagen 2007) at various level. There are a lot of reports devoted to evaluate vulnerability of climate change on a national and global level (Easterling 1996; Smit and Smithers 1994; Ikerd 1997; FAO 2003; Stern 2006; Barnosky 2008; Fischer et al. 2005; IPCC 2007; Rosenzweig et al. 2002; Warren et al. 2006; Reilly et al. 2001; Reinsborough 2003; Willis et al. 2004; Wilson and Tyrchniewicz 1995; Milestad and Darnhofer 2003; McCarthy et al. 2001) but unfortunately more comprehensive and site specific vulnerability assessment that would have been suitable to plan possible adaptation measures at local/regional scales are yet to be carried out.

Finally, Vogel et al. (2007) suggests that vulnerability assessment is required across spatial and varying temporal scales, e.g. assessing present vulnerability at varying scales (e.g. local to household level as well as national assessments) using the Human Development Index or other indicators and mapping of vulnerability by the study of Vulnerability and global environmental change in the year 2001. Technical adaptations to climate change in many developing countries where the issue of climate change is overshadowed by a number of immediate development priorities such as poverty eradication; food and water security; health and natural resource management; local air—water pollution (Chapter by Surender Kumar and Parmod Kumar (Chap. 17); Klein et al. 2004; Brown 2008; Downing et al. 1997; Guilmoto 1998; Ezra and Kiros 2001; Verchot et al. 2007). This has become a key issue in climate change negotiations, where much of the attention focused on sources of funding, as well as the emerging issues of equity and compensation (Yin et al. 2000) are going to bear the brunt of climate change and suffer most from its negative impacts (Verchot et al. 2007). Looking at vulnerability as an end point has played a useful role in measuring the extent of the climate change problem, and weighing the costs of impacts and adaptations against the costs of greenhouse gas mitigation (Xinhua et al. 1999; Vavrus et al. 2008). Future climate change scenarios and estimates of impacts can provide a useful contextual frame for studies that take climate change as a starting point (Nordlund 2008; Li et al. 2008). However, to understand vulnerability as well as adaptation, "greater insights can be gained from closely looking around and closely looking back at microscopic level that how farmers changes their way of living in changing climatic condition rather than from looking forward" (Adger 2003; Fuessel 2007; Thomas 2008; Abbas 2015). Thus, transdisciplinary and interdisciplinary approaches require for developing the climate resilient society and ecology.

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