Climate Change and Adaptation: Recommendations for Agricultural Sector

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Abstract

Agriculture is a climate-sensitive enterprise. Agricultural sector should also employ appropriate strategies and approaches to adjust to climate change. Due to the significance of this issue, the main purpose of this chapter is to explain the necessity of climate change adaptation strategies in the agricultural sector. In order to achieve this purpose, some specific objectives including "characterizing the meaning and different kinds of adaptation to climate change," "clarifying the relationship between adaptation to climate change and agricultural sustainability," "positioning adaptation theory in agricultural development theories and discourses," "introducing prerequisites and requirements of adaptation to climate change in developed and developing countries," "explaining approaches to climate change vulnerability assessment," and "introducing a comprehensive approach to climate change adaptation in agricultural sector" were defined. The main adaptation approaches to climate change include hazards-based and vulnerability-based approaches. The former focuses on gradual effects of climate change. That is, according to hazards-based approach, the assessment of agricultural adaptation to climate change is undertaken through predictions made in the field of climate change and designed on the basis of various scenarios, while the latter assesses future climate change trend by considering current climate risks. In other words, vulnerability-based approach places high emphasis on the social factors determining farmers' and systems' ability to combat climate damages. It is worth mentioning that one of the main drawbacks

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of these approaches is lack of emphasis on adaptation feedbacks. Furthermore, the results emphasized that although there is no a one-size-fits-all approach for adaptation to climate changes, being aware of the experiences of other countries (with similar climatic and geographical conditions) and adaptation strategies employed by them can definitely be useful for communities dealing with negative impacts of climate change.

Keywords

Climate change · Adaptation · Vulnerability · Agriculture · Resilient agriculture · Agricultural sustainability

5.1 Introduction

Climate is the average weather conditions during a 30–35 years' time period, while weather, whose elements consist of temperature, pressure, humidity, and precipitation, is atmospheric conditions during a day. In other words, climate is the average weather conditions in a certain area during a certain period of time. Based on the most basic definition of climate change, the phenomenon refers to changing weather conditions in an area consisting of average temperature, precipitation, and humidity conditions (Bradley et al. 1985). As a matter of fact, climate change refers to changes in meteorological conditions during a long period of time, namely centuries (Hageback et al. 2005). According to the definition presented by Intergovernmental Panel on Climate Change (IPCC), what is meant by climate change is, in fact, any changes caused by natural events and human activities during a certain period of time (Comoe et al. 2014). Also, long-term fluctuations in temperature, precipitation, wind, and other aspects of climate are related to climate change effects, which have major impacts on agriculture and food security (Molua 2002; Valizadeh et al. 2018).

The world's climate is changing with an unprecedented rapidity in the present era, having negative effects on the world's different areas (Adger et al. 2003; Bijani et al. 2017; Valizadeh et al. 2019). "*The global mean surface temperature has increased about 1 ^{o}C above pre-industrial levels and it is likely to reach 1.5 ^{o}C between 2030 and 2052 if it continues to increase at the current rate*" (Venkatramanan et al. 2020a). For instance, Table 5.1 presents predictions made by IPCC, concerning effects of climate change on various environmental elements in Asia. Given the variety of natural changes and human activities in the recent century, climate change is regarded as one of the main dangers, threatening sustainable development in various aspects such as environment, human health, food safety, economic activities, human resources, and infrastructures (IPCC 2001).

"*Agriculture is a climate-sensitive sector. Climate variability and climate change affects the agricultural production and productivity across the world*" (Venkatramanan and Shah 2019). Due to the prevailing condition of "poverty," "income instability," and lesser adaptive capacity, the developing countries are more vulnerable. The modern climate change demands transformation of present-day

Table 5.1 IPCC predictions concerning effects of climate change on various environmental elements in Asia

Area	Food and forest	Biodiversity	Water resources	Coastal ecosystem	Human hygiene	Settlement
Northern Asia	H-1	M-2	M-1	L-1	L-1	M-0
Dry and semi-dry	H-2	L-1	H-2	L-1	M-1	M-1
Temperate Asia	H-2	M-1	H-2	H-2	M-2	H-2
Tropical Asia	H-2	M-2	H-2	H-2	M-1	M-2

Table signs: *1*: High vulnerability, *2*: Moderate vulnerability, *0*: No vulnerability; *H*: High, *M*: Moderate, *L*: Low

agriculture sector to achieve food and nutritional security (Venkatramanan et al. 2020b). Integrating mitigation and adaptation strategies in agriculture sector paves way for resilient and smart agriculture (Venkatramanan et al. 2020b). Agriculture is a major source of revenue for rural communities and one of the main factors helping the economy of most developing countries. Meanwhile, it is the most vulnerable sector to dangers and global effects of climate change (Smit and Skinner 2002). According to Dinar and Mendelsohn (2011), climate variables influencing agricultural activities and natural resources are as follow:

- Change in temperature: this factor directly affects plant growth, livestock (reproduction, dairy productions), vermin spread, soil humidity, and evaporation of water resources.
- Change in precipitation: this factor impacts on the degree of water available for products, livestock forage, and river flows.
- Change in carbon dioxide: this factor affects plant growth by bringing changes in basic photosynthesis fuel and the degree of water needed for plant growth.
- Tragic phenomena (flood, conflagration, hurricane, etc.): factors like these affect production conditions, leading to destruction of agricultural products and drowning of livestock.

Currently, around the world, some climate change effects have been reported, including increase in levels of drought in dry and semi-dry countries (Keshavarz et al. 2013). Meanwhile, empirical evidence reveals that the degree of countries' vulnerability to climate change varies. In other words, inhabitants of developing countries depend for their livelihood on natural resources (e.g. water, soil, and pasture), causing them to be more vulnerable to climate change in these countries (Barak 2006). Therefore, if achieving sustainable development is among the main policies of developing countries, whose economy is dependent on natural resources, they need to adjust their agricultural sector to climate change (Stakhiv and Stewart 2010). Adaptation of agricultural sector to climate changes is of great importance,

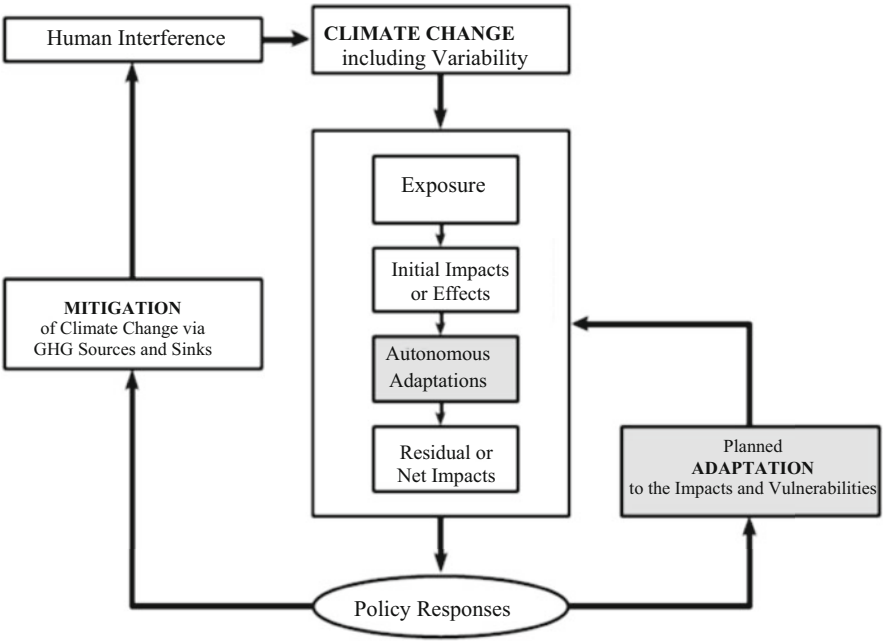

Fig. 5.1 Places of adaptation in the climate change issue. (Source: Smit et al. 2001. Available from https://www.ipcc.ch/site/assets/uploads/2018/03/wg2TARchap18.pdf. Accessed on 9 Apr 2020)

since it facilitates the selection of best policies and reduces the vulnerability of different groups. It should also be mentioned that the adaptation of agricultural sector to climate changes can decrease the costs (Grothmann and Patt 2005). Adaptation to climate change should be undertaken in such a way that (1) ecosystem stability is maintained, (2) food security is not endangered, and (3) the possibility of social and economic development of groups and communities, which are vulnerable to climate change, is provided (Smit et al. 1999). Therefore, the degree to which agriculture is exposed to damages inflicted by climate change is dependent on the degree of consequences and ability to adjust to climate change(Karimi et al. 2018a, b; Maleksaeidi et al. 2015; Keshavarz et al. 2014) (Fig. 5.1).

5.2 Concept of Adaptation to Climate Change

Adaptation refers to a system's characteristics and behaviors, which improve its ability to combat external pressures (Brooks 2003). It is a response to a shock caused by humans or nature before, during, or after it has occurred, resulting in the stability or improvement of social-ecological systems (Folke 2006; Renaud et al. 2010; Berrang-Ford et al. 2011). Modification in ecological and socioeconomic systems

in response to effects and outcomes of actual or expected weather stimuli is called climate change adaptation (Plummer et al. 2013).

A review of the related literature reveals that there are different kinds of adaptations. Studies have classified adaptation into five categories: (1) farm and technology management, (2) farm financial management, (3) diversity in and out of farm, (4) government interference, and (5) knowledge and network management.

Also, Iglesias et al. (2007) divides adaptation into three groups, namely managerial, technical/instrumental, and infrastructural. Kinds of adaptation or, in other words, adaptation methods can be differentiated on the basis of various characteristics (Bryant et al. 2000). Different aspects of differentiating adaptation are as follow (Fussel 2007; Smit et al. 1999):

- Areas sensitive to climate change: adaptation should be undertaken in all areas under the influence of climate change, namely agriculture, forestry, water management, public health, and disaster prevention.
- The kind of climate threat: adaptation should be undertaken in a series of climate threats occurring at present or in the future, namely observed or expected changes in climate, climate fluctuation, or climate catastrophes.
- Climate change predictability: some aspects of future climate change can be predicted with high certainty (e.g., changes in average temperature), while with regard to some other changes such certainty is not present (e.g., changes in severity and occurrence of hurricane).
- Non-climate conditions: environmental, economic, political, and cultural conditions affect climate change adaptation as well. In should be noted that the non-climatic conditions vary from one area to another.
- Purposefulness: adaptation can be undertaken unconsciously, pre-planned, and purposefully. Unconscious or spontaneous adaptation is of that kind occurring as a response to climate stimuli. As shown in Fig. 5.1, this kind of adaptation happens when faced with early effects of climate change, and government institutions play no role in undertaking such an adaptation. On the contrary, planned adaptations can occur as a response or prediction.
- Timing: planned adaptation can occur as a response (aftereffects of climate change emerge), or proactive and prediction-oriented (before the effects of climate change emerge).
- Planning time limit: planned adaptation time limit can range from short period of time to decades as climate changes.
- Combination: adaptation encompasses different kinds of activities, namely structural, legal, institutional, financial, and technological.
- Activists: various groups of people might get involved in climate change during the adaptation process. Here, government and private institutions play a major role in adaptation.

Also, adaptation to climate change can be examined on the basis of people's responses to this phenomenon. As it is depicted in Fig. 5.2, climate change adaptation can be undertaken in the form of "bear losses," "share losses," "modify threats,"

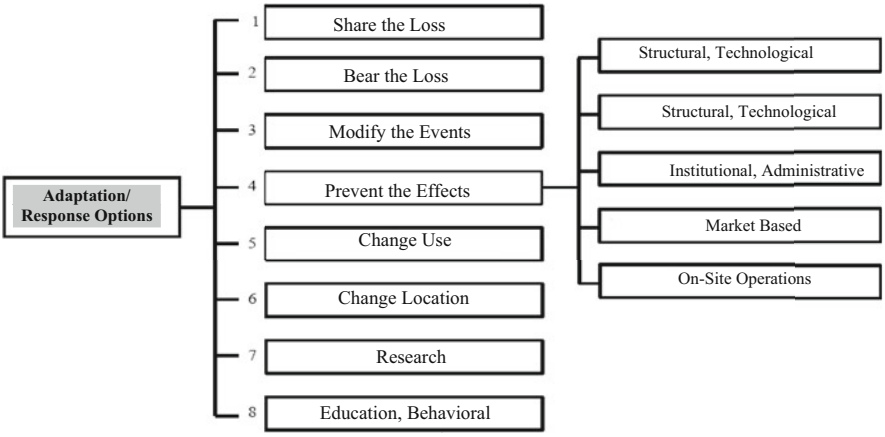

Fig. 5.2 Classification of adaptation options. (Source: Burton et al. 1993)

"prevent effects," "change in use," and "change location" (Burton et al. 1993). It is obvious that society structures, institutional arrangements, and public policies play a role in climate change adaptation (Fig. 5.2).

5.3 Agricultural Sustainability and Adaptation

Sustainability has been mainly defined as the capacity to meet today's goals without compromising the future capacity to achieve them (Maleksaeidi and Karami 2013). This definition stems from the definition of sustainable development presented by the Brundtland Commission in 1987. The concept of sustainability has varied throughout history, and authors have reported different dimensions about it (Keshavarz et al. 2010). It seems that the concept of sustainability is similar to "beauty in the eyes of viewer" (Swanson et al. 2005). This diversity, in turn, leads to diversification of sustainable agriculture. Nevertheless, sustainable agriculture is defined as an integrated cultivation and animal husbandry system that has a special situational application. The elements of this type of agriculture are (Hayati 2017):

- Providing human food needs
- Increasing environmental quality and natural resources, based on agricultural economy
- Leading to use of renewable and agricultural resources and integrating biological cycles in an efficient way
- Sustainability of agricultural functions
- Increasing quality of life of farmers and community as well

"*Agricultural sustainability includes recognition of feedback interaction in ecosystems that enable the sytem to be controlled and self-regulated; maintaining*

the stability and sustainability of the ecosystem through the use of free services of nature and increasing the species and landscape diversity" (Venkatramanan and Shah 2019). Sustainable agriculture involves economic, ecological, and social sustainability. While economic sustainability reflects the crop productivity, ecological sustainability refers to "the preservation and improvement of the natural environment" and social sustainability reflects self-reliance, equality, and improved quality of life (Hayati et al. 2011; Forouzani and Karami 2011; Forouzani et al. 2012). For instance, gender equality and gender mainstreaming play a significant role in improving agricultural productivity, natural resource management, and social sustainability (Venkatramanan and Shah 2020). It is obvious that each of the scholars concentrated on different dimension of sustainability and revealed new aspects of it. But the main commonality in all of these theories is "the role of human in managing the other aspects of sustainability."

The literature shows different understandings about concepts of adaptation and sustainability (Tendall et al. 2015). If we accept the definition of Brundtland Commission, and also define adaptation as the system's characteristics and behaviors that improve its ability to combat external pressures, it will be obvious that these two concepts could be complementary. Sustainability induces adaptation, and adaptation leads to sustainability (through capacity building of a system to properly function prior, during, and after the pressure). This type of association between adaptation and sustainability has been confirmed by Keenan (2016) and Maleksaeidi and Karami (2013). Based on Keenan (2016), adaptation may be dependent on the periodic sustainability of certain systems to provide the resources and capital for the adaptation processes that prevent the subject, host, and/or system from crossing the frontier that results in loss or failure.

Moreover, Table 5.2 highlights the different aspects that sustainability and adaptation share, including a broader framework oriented toward resource trade-

Table 5.2 Comparison of sustainability and adaptation

Comparison characteristics	Sustainability	Adaptation
Social construction	Triple bottom-line balancing	Manage risks and long-term hazards
Primary policy principle	Resource trade-offs (natural capital)	Resource trade-offs (human and financial capital)
Actors	Multi-actor	Multi-actor
Policy setting	Cooperation	Cooperation
Tasks	System solutions for individuals	Individual solutions for systems
Principle for action	Proactive	Reactive and proactive
Primary scope	Global	Local
Focus	Products and process networks	Products and process networks
Technology	Integrated processes and innovations	Integrated processes and innovations

Source: Keenan (2016)

offs, cooperation, and a focus on products, processes, and innovation. In more immediate terms, the ends to these common values are seemingly drawn only by the distinction between climate mitigation and risk mitigation. However, the conceptual conflict between sustainability and adaptation has been widely cited in various domains of scientific literature (Keenan 2016).

5.4 Adaptation in Agricultural Development Theories

In the evolution process of development, the concept of "sustainable development" was obtained, and this understanding is often considered to be an ideal development approach (Cobbinah et al. 2015). Sustainable agriculture has been developed as a response to the changes and problems of agricultural sector. But there are two theoretical perspectives, including De-Modernization (DM) theory and Ecological Modernization (EM) theory in this context, that are known as bases of coping with agricultural environmental challenges and provide a conceptual framework for sustainable agricultural development (Rezaei-Moghaddam et al. 2006). DM assumes that the environmental degradations stem from the modernization, and the solution is going back to the traditional systems of agriculture. In contrast, EM accepts that modernization has induced negative impacts on environment. It also assumes the reason for environmental degradation is inadequate advances in modernization. Therefore, based on this theory, the solution for all these problems is hyper-industrialization, modern technology, ecological economy, strong modern environmental state, reform ideology, and changing discourses (Asadi and Naderi 2015).

These theories have serious problems with regard to how transformation to sustainable agriculture occurs, and, therefore, they assume a linear mode of thinking about development that is heavily dependent on technology (highly modern or traditional) (Rezaei-Moghaddam et al. 2006). On the other hand, the emergence of adaptation theory in development debates has increased the problematic dimensions of EM and DM theories because adaptation uses different elements of EM and DM, in order to accomplish sustainability. In other words, this paradigm has a more flexible nature compared to EM and DM. For instance, in EM and DM, the traditional knowledge and scientific knowledge contradict each other. But adaptation paradigm may use both of them at the same time for attaining sustainable development. The research of Maleksaeidi and Karami (2013) is in line with this notion. Maleksaeidi and Karami (2013) argued that one of the most important strategies farmers adopt to deal with water scarcity is combination of different types of knowledge (local and science). Based on DM, when farmers are faced with an environmental problem such as water scarcity, they consider returning to agricultural practices based on local or traditional knowledge such as diversification of agricultural activities and/or creation of a multifunctional agriculture. Adaptation theory not only uses these diversifications of agricultural activities but also tries to use EM teachings (such as improvement in new agricultural irrigation systems) as a combined strategy to deal with water scarcity. However, the adaptation could be supposed as a paradigm that is not in conflict with EM and DM. In other words, attaining

sustainable agriculture through adaptation is not impossible even during problematic conditions.

5.5 Requirements of Adaptation to Climate Change: The Experience of Developed and Developing Countries

Although climate change has gained recognition as a global phenomenon, the ability of various countries to adjust to climate change differs. Given that developed countries are in a more economically sustainable situation, possess more appropriate institutions and infrastructures, and have higher access to capital, information, and technology, they enjoy higher climate change adaptive capacity compared to developing countries (Toman and Bierbaum 1996). Moreover, countries, which have more powerful social institutions and support different groups and individuals at appropriate levels of capital and knowledge, enjoy higher adaptive capacity (Smit and Wandel 2006). On the other hand, although developing countries have adopted various climate change adaptation strategies, namely indigenous methods of adaptation to climate change, their ability to provide an appropriate and on-time response to climate change is limited as they do not possess infrastructure and economic power needed for confronting with climate change impacts and consequences (Smit and Wandel 2006). The biggest obstacles to adaptation in these countries are (Fussel and Klein 2006; Mizina et al. 1999):

- Financial obstacles (severe price changeability, lack of money supply, unavailability of budgets)
- Legal/institutional obstacles (poor institutional structures, institutional instability)
- Social/cultural obstacles (social conflicts, improper use of lands)
- Technological obstacles (existing technologies, accessibility to technologies)
- Informational/educational obstacles (lack of information concerning kinds and degrees of climate change vulnerability, lack of trained forces)

Moreover, a study conducted by Rosenzweig and Parry (1994) revealed that climate change effects differ in developed and developing countries in such a way that damages inflicted by climate change on developing countries' agriculture are higher than those that occur in developed countries. In addition, since developing countries and poorer countries are faced with more technological and institutional constraints when undertaking climate change adaptation, their adaptation incurs higher costs (Smit and Wandel 2006). Also, in comparison with industrialized countries, developing countries have lower levels of adaptive capacity since their economy is highly dependent on climate resources (Barak 2006).

Although climate change adaptation is a necessity for countries, the way in which different countries and areas adjust to climate change varies. That is, they should undertake climate change adaptation in accordance with their economic, human, natural, and social capacities. Table 5.3 reveals the variation in climate change impacts and strategies proposed to adjust to climate change in different countries

Table 5.3 Adaptation and capacity in the regions

Key findings	Sector
Adaptation potential in socioeconomic systems is relatively high because of strong economic conditions; stable population (with capacity to migrate); and well-developed political, institutional, and technological support systems.	Europe
The response of human activities and the natural environment to current weather perturbations provides a guide to critical sensitivities under future climate change.	
More marginal and less wealthy areas will be less able to adapt; so without appropriate policies of response, climate change may lead to greater inequities.	
Adaptation measures have potential to reduce climate-related losses in agriculture and forestry.	Latin America
There are opportunities for adapting to water shortages and flooding through water resource management.	
Adaptation measures in the fishery sector include changing species captured and increasing prices to reduce losses.	
Strain on social and economic systems from rapid climate and sea-level changes will increase the need for explicit adaptation strategies. In some cases, adaptation may yield net benefits, especially if climate change is slow.	North America
Stakeholders in most sectors believe that technology is available to adapt, although at some social and economic cost.	
Adaptations such as levees and dams often are successful in managing most variations in the weather but can increase vulnerability to the most extreme events.	
Potential for adaptation is limited in indigenous communities that follow traditional lifestyles.	Polar Regions
Technologically developed communities are likely to adapt quite readily, although the high capital investment required may result in costs in maintaining lifestyles.	
Adaptation depends on technological advances, institutional arrangements, availability of financing, and information exchange.	
Adaptive measures would enhance flexibility and have net benefits in water resources (irrigation and water reuse, aquifer and groundwater management, desalinization), agriculture (crop changes, technology, irrigation, husbandry), and forestry (regeneration of local species, energy-efficient cook stoves, sustainable community management).	Africa
Without adaptation, climate change will reduce the wildlife reserve network significantly by altering ecosystems and causing species emigration and extinctions. This represents an important ecological and economic vulnerability in Africa.	
Risk-sharing approach between countries will strengthen adaptation strategies, including disaster management, risk communication, emergency evacuation, and cooperative water resource management.	

(continued)

Table 5.3 (continued)

Key findings	Sector
Adaptations already are required to deal with vulnerabilities associated with climate variability, in human health, coastal settlements, infrastructure, and food security. The resilience of most sectors in Asia to climate change is very poor. Expansion of irrigation will be difficult and costly in many countries.	Asia
Adaptive capacities vary between countries, depending on social structure, culture, economic capacity, and level of environmental disruptions. Limiting factors include poor resource and infrastructure bases, poverty and disparities in income, weak institutions, and limited technology.	
Adaptation strategies would benefit from taking a more systems-oriented approach, emphasizing multiple interactive stresses, with less dependence on climate scenarios.	
Adaptations are needed to manage risks from climatic variability and extremes. Pastoral economies and communities have considerable adaptability but are vulnerable to any increase in the frequency or duration of droughts.	Australia and New Zealand
Adaptations will be viable only if they are compatible with the broader ecological and socioeconomic environment, have net social and economic benefits, and are taken up by stakeholders.	
Adaptation responses may be constrained by conflicting short- and long-term planning horizons.	

Source: Smit et al. (2001). Available from https://www.ipcc.ch/site/assets/uploads/2018/03/wg2TARchap18.pdf. Accessed on 9 Apr 2020

(Smit and Pilifosova 2003). For instance, adaptation methods used by European and American countries are different from those employed by African and Asian countries. While in Europe and America, favorable economic, technological, and infrastructural capacities have paved the way for reduction in losses caused by climate change, poor infrastructure in African and Asian countries has increased the degree to which different groups are vulnerable to climate change.

Adaptation to climate change is one of the most interesting topics for researchers in many countries, and many studies have been carried out on this subject. In order to clarify some of the most significant results of these studies around the world, we tried to summarize six of these studies in the following section.

Case 1: Adaptation to Climate Change in Afghanistan: Evidence on the Impact of External Interventions

In this study, Jawid and Khadjavi (2019) attempted to offer some evidence on the impact of the agriculture-related external support on farmers' adaptation to climate change in the central highlands of Afghanistan. To this end, authors collected primary data from 1434 farmers whom they interviewed across 14 districts in Bamiyan, Ghazni, and Diakundi provinces. Researchers applied quasi-experimental econometric methods, including an endogenous switching regression analysis, to

estimate the treatment effects on various adaptation-related outcomes. The results of this study showed significant impacts of support interventions on the use of improved types of seeds and farmers' access to irrigation water. Further impacts on the risk of flood, and economic and financial, as well as government and institutional adaptation constraints appear to be significant, but sensitive to the existence of unobserved factors. The study concludes that farmers perceived changes in the climate, and most of them tried to adapt by employing measures available to them. The impact of external support has been partially effective in addressing immediate and short-term farming challenges related to climate change and extreme weather events. They, however, have not been effective in treating long-term fundamental climate change–related risks.

Case 2: Social Representations of Climate Change and Climate Adaptation Plans in Southern Brazil: Challenges of Genuine Participation

This study was carried out by Bonatti and her colleagues in 2019. The main objective of their study was to present a case study (Tapera da Base) within the context of the project, "Climate Change and Vulnerable Populations in Brazil," which discussed the problems associated with climate change adaptation and risk-reducing activities. The methodology adopted involved identifying local development organizations, focused group discussion, interviews, and survey among families in the most vulnerable areas. The main results showed that Tapera residents do not associate the possible increase in their vulnerability to climate dynamics. They pointed to areas such as education, sanitation, and social assistance, as their most important local problems, thus not including climate change. They recommend that to generate genuine participation, it is crucial to create initiatives that promote a social learning space for residents to evaluate their self-state of vulnerability and possibilities of development. Therefore, climate change can make sense, and the responses at the community level will be created in the context that shape how climate risk is perceived, prioritized, and managed.

Case 3: Spatial Planning and Climate Change Adaptation Assessment: Perspectives from Mdantsane Township Dwellers in South Africa

In their study, Busayo et al. (2019) adopted a mixed-method approach to examine township spatial planning and climate change adaptation in identifying potentialities for an integrated approach. Mdantsane case study as one of the largest townships in South Africa was assessed as a unique landscape that was reminiscent of apartheid legacies to improve the people's climate change adaptation under urban poverty, lack of basic facilities, and other environmental challenges. In keeping with a case study design, they collected the required data using open- and close-ended survey forms with an interplay of geographic information system (GIS) and remote sensing techniques. This study revealed that Mdantsane is extremely susceptible to the impacts of climate change due to their built-up and natural environment setup as well as the existing interrelations. Thus, comprehensive integration of spatial planning was recommended for proofing, health, well-being, and resilience. Consequently, recommendations to seek strategic intervention and planning were made to

sustain adaptation of residents to climate change in the future with specific focus to reduce climate and environmental risks in Mdantsane Township.

Case 4: Evaluating Participatory Techniques for Adaptation to Climate Change: Nepal Case Study

In this study, Khadka et al. (2018) mainly examined the role of participatory tools and techniques with the potential to identify the level of vulnerability and likely adaptation measures to increase the forest resilience capacities of communities where the community-based climate change adaptation plan of action (CAPA) has been prepared. In total, 13 participatory qualitative tools were evaluated against 15 criteria for identifying their performance in nine CAPA groups, representing three geographical regions of Nepal. The results of multivariate analyses indicated how CAPA groups evaluate the likelihood of climate change impact, determining the vulnerability of specific ecosystem services and understanding the possible local adaptation measures. These scholars also cited that the integration of adaptation planning in local institutions, in order to deal with different ecosystem-based adaptation options, along with identification of climate change scenarios, impacts, trade-offs, synergies, and the sensitivity of management problems, is highly recommended.

Case 5: Psychosocial Drivers for Change: Understanding and Promoting Stakeholder Engagement in Local Adaptation to Climate Change in Three European Mediterranean Case Studies

The goal of this work, which was directed by Luis et al. (2018), was to explore whether or not the intention of engaging could be understood (Study 1) and promoted (Study 2), by using an extension of the theory of planned behavior. In Study 1, stakeholders from three European Mediterranean case studies were surveyed: Baixo Vouga Lagunar (Portugal), Schéma de Cohérence Territoriale Provence Méditerranée (France), and the island of Crete (Greece) ($N = 115$). Stakeholders' intention of engaging was significantly predicted by subjective norm (which was predicted by injunctive normative beliefs toward policymakers and stakeholders) and by perceived behavioral control (which was predicted by knowledge of policy and instruments). Study 2 was conducted in the Baixo Vouga Lagunar and consisted of a two-workshop intervention, where issues on local and regional adaptation, policies, and engagement were presented and discussed. A within-participants comparison of initial survey results with results following the workshops indicated that these were successful in increasing stakeholders' intention of engaging. This increase was paired with (a) an increase in injunctive normative beliefs toward policymakers and, consequently, in subjective norm and to (b) a decrease in perceived complexity of planning local adaptation and an increase in knowledge regarding adaptation to climate change.

Case 6: Coastal Management and the Political-Legal Geographies of Climate Change Adaptation in Australia

This study, which was carried out by O'Donnell in 2018, connects critical legal geography and coastal climate change adaptation. This study was conducted in New South Wales, Australia. In attending to the political-legal nature of coastal manage ment through the lens of legal geography, this case study illustrated the complexities of law's role as both a driver and a barrier to coastal climate change adaptation, through a detailed review and analysis of repeated legislative reform between 2009 and 2018. This not-yet-documented analysis serves to highlight a shifting legal landscape and the politics of coastal climate change adaptation. It also illustrates how private property rights have been used as both a sword and a shield to advance dominant interests. The study offers specific examples of ways private property discourses have been used to muddy the waters of adaptation responses and how private property discourses can pervade, dissuade, and undermine land-use manage ment policies even as such policies aim to achieve more harmonious coastal management.

5.6 Approaches to Climate Change Vulnerability Assessment

Different national and international organizations have introduced a variety of approaches to the assessment of climate change effects and adaptation. The most important adaptation assessment guides include IPCC (Carter et al. 1994), international guidebook United States Country Study Program—USCSP (USCSP 1994), United Nations Environment Programme—UNEP guidebook, United Nations Development Programme-Global Environment Finance (UNDP-GEF) policy framework (Burton et al. 2005), and adaptation to climate change through integrated risk assessment (ADB 2005).

Hazards-based and vulnerability-based approaches are among the common approaches to the assessment of climate change effects and adaptation (Burton et al. 2005). The former focuses on gradual effects of climate change, according to which assessment of adaptation to climate change is carried out through predictions made on the basis of various scenarios in the field of climate change. Accordingly, little attention is paid to non-climate factors affecting adaptation. IPCC, USCSP, and UNEP have put considerable emphasis on hazards-based approach (Fussel 2007). Even though different studies have revealed that the assessment of adaptation to climate change on the basis of hazards-based approach is of high significance in identifying climate change risks, results obtained from these studies cannot be regarded as a useful tool for making purposeful policies to rapidly reduce effects of climate change (O'Brien 2000; Burton et al. 2002).

Excessive emphasis on modeled prediction of climate and climate change effects is one of the important constraints of hazards-based approach as the odds are that scenarios and various models of climate change do not exist for areas and locations, in which climate change adaptation programs are to be implemented. Also, most of the predicting models of climate change devote a long-term time period, which can

prove inappropriate for many adaptation programs and farmers. For instance, long-term predictions cannot help farmers in making decisions regarding annual plantation and short-term use of water resources. Moreover, hazards-based assessments pay little attention to current risks, concerning natural climate fluctuation and non-climate stimuli. Also, this assessment approach disregards key uncertainties in policymaking and developing adaptation policies. Disregarding nontechnical aspects of climate change (e.g., adaptive capacity and social determinants of farmers' vulnerability) and wider aspects of climate change adaptation policy (e.g., developing sustainable economy and management of rural resources) are among other defects of hazards-based approach (Fussel 2007).

On the contrary, vulnerability-based approach assesses the future trend of climate change with regard to current climate risks with a considerable emphasis on social factors determining farmers' and systems' abilities to combat climate losses. Vulnerability-based assessments take into consideration past climate risk management and get farmers involved in assessment and adaptation from the beginning, directly connecting climate change adaptation with their activities. Therefore, even at the absence of a precise and reliable climate change prediction scenario, assessments conducted using this approach can yield fruitful results. Yet, the approach has disadvantages as well, including excessive dependence on views and judgments of agriculture experts, limited comparability in different areas due to qualitative nature of results obtained from assessments, and also lack of a certain methodology (Fussel 2007). Hazards-based and vulnerability- based approaches take into account different perspectives regarding climate change risks. The former is helpful in raising awareness of farmers about existing problems and identifying research priorities. Also, employing this approach in agriculture is recommended where current risks are effectively controlled, and long-term decision-making for agricultural adaptation are taken into consideration, resources needed for developing various scenarios are available, and also where future climate change is sufficiently predictable. On the contrary, vulnerability-based approach is helpful in identifying prioritized areas for implementing climate change adaptation programs and evaluating the degree to which activities carried out to adopt agriculture to climate change have been effective. In addition, applying the vulnerability-based approach is highly favorable in adjusting agriculture to climate change in cases where current climate risks cannot be brought effectively under control, non-climate factors play a significant role in intensifying effects of climate change on adjusting agriculture community to climate, adaptation planning horizons are not far, data and resources needed for developing climate change scenarios are limited, and, finally, where there is uncertainty with regard to effects of climate change in the future (Fussel 2007).

Accordingly, given that many developing countries do not possess data and resources needed for climate change prediction and modeling, and also take into consideration policies related to gaining short-term benefits resulting from controlling climate risks, employing vulnerability-based approach is highly recommended in these countries. It should be noted that grounds for assessing adaptation to climate change on the basis of hazards-based approach should also be provided in developing countries, as they are regarded as two complementary

approaches (Burton et al. 2005). Therefore, selecting and employing agricultural adaptation approaches in developing and developed countries depend on climatic conditions of every area. That is, climate, environmental, social, and political conditions of different countries play crucial roles in the employment of agricultural adaptation approaches.

5.7 The Need for Development of a Comprehensive Approach to Climate Change Adaptation

Increased recognition of climate change effects and growing emphasis laid on climate change outcome by policymakers in different countries have led to changes in the global community's orientation and gradual development of theoretical discussions, concerning climate change adaptation. Currently, the theory of climate change adaptation has gained considerable attention and also a variety of approaches to, and methods of, adaptation assessment are taken into consideration (Burton et al. 2002).

Currently, according to a review of related literature, past studies regarding climate change adaptation have placed their emphasis on concepts such as complexity, adaptive social-ecological systems, and inadequacy of common approaches in explaining complexities concerning climate change adaptation (Cornell et al. 2010). Therefore, the need for a more precise and comprehensive assessment of climate change adaptation is felt. Accordingly, existing uncertainties regarding prediction of future climate changes and its effects should be effectively identified and also complex processes of climate change adaptation, which encompasses climatic and non-climatic stimuli, should be properly taken into account (Kalaugher et al. 2013). Mastrandrea and Schneider (2010) hold that assessments of climate change adaptation should be simultaneously conducted in the form of top-down and bottom-up approaches in such a way that various beneficiaries, climate scientists, and social sciences scholars can play a direct role in the assessment of adaptation to climate change.

As it was shown in part "A" of Fig. 5.3, top-down approaches, which are based on modeling (e.g., hazards-based approach), mostly reflect a mechanized view on adaptation of agricultural systems to climate change, on the basis of which it is thought that developed knowledge results from scientific methods, and, accordingly, it is objective and repeatable (Kalaugher et al. 2013). This approach seeks to exhibit causal relationships to provide the possibility of predicting the climate change adaptation process. According to top-down approaches, different scenarios of climate change are regarded as a basis for assessing future effects of climate change, and adaptation needs are determined on the same predictions. Moreover, in these approaches, adaptation to climate change is, to a great extent, separated from other processes and social activities, and adaptation needs are obtained through scientific analyses (Fussel 2007). It should be noted that top-down approaches are emphasized in IPCC technical guide (Carter et al. 1994). On the contrary, bottom-up approaches (e.g., vulnerability-based approach) make use of social sciences methodology,

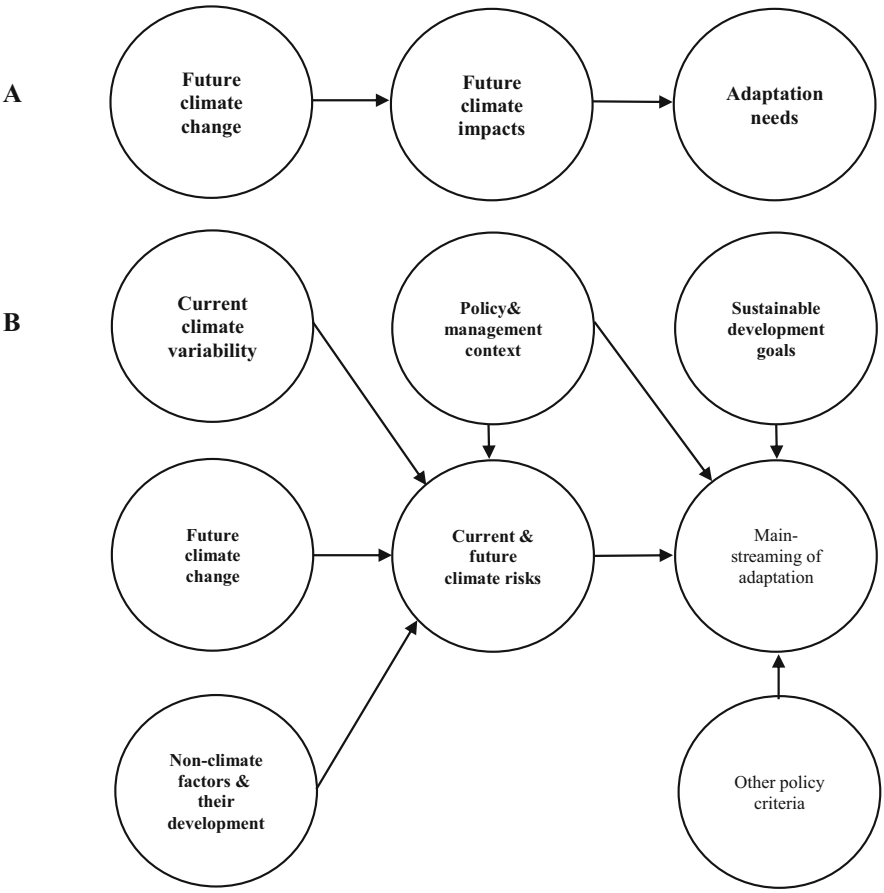

Fig. 5.3 Development of approaches to climate change adaptation: (**a**) linear hazards-based approach, (**b**) complex and comprehensive approach to adaptation. (Source: Fussel 2007)

according to which knowledge is developed in the form of narrative, commentary, and criticism.

The knowledge yielded from this approach is context-based and dependent on certain areas and conditions under examination (Miller et al. 2008). If top-down and bottom-up approaches are to be employed jointly to assess adaptation to climate change, a more complicated approach is required, a sample of which is depicted in part B of Fig. 5.3 (Füssel 2007). The new approach, which is extracted from current approaches to climate change adaptation, seeks to present a more comprehensive description, regarding present and future climate change risks. Not only does the new complex approach take into consideration present climate changes, but it also examines the future trends of climate change. In addition, the approach takes account of both climatic and non-climatic factors affecting adaptation to climate change.

Also, risk assessment is conducted through experiences obtained from past management regarding climate risks, and recommendations related to adaptation to climate change are presented on the basis of their potential for reducing present and future climate changes. It should be noted that recommendations should be in line with other policies such as sustainable development goals. This approach is emphasized in UNDP-GEF policy-making framework (Burton et al. 2002).

5.8 Conclusion

The main purpose of this chapter was to highlight the importance of climate change adaptation strategies in agricultural sector. As it was previously mentioned, agricultural sustainability and adaptation to climate change are strongly interdependent, and the concept of adaptation refers to a system's characteristics and reactions, which increase its capability to be able to cope with external pressures. Being able to cope with these pressures can pave the way for attaining sustainability in agricultural sector. The future of agricultural sector around the world depends on whether this sector is able to mitigate negative impacts of climate change and manage the resources, including water, soil, land, and so on, in a sustainable manner. This would require a set of actions that allow farmers access to the current technologies. Also, investing in research is necessary, in order to enable land and water management to cope with uncertain future. In this regard, more efforts should made toward investment in water conservation infrastructure, development of new technologies, investment in enhancing farmers' capacity to adapt to climate change, and investment in risk management. Furthermore, ensuring economic efficiency in the use of agricultural resources and taking measures to promote water and soil conservation at the farm level are priority areas for action. Also, assessment of the effectiveness and sustainability of water management strategies is needed. For instance, the excessive exploitation of groundwater during drought is not sustainable and should be prohibited.

Some of the policy measures, including educational programs, have no visible results in a short period of time. But they can have really significant effects on the mitigation of the effects of climate change. Lack of information and awareness has increased the risks and negative impacts of climate change in most countries around the world. In other words, many countries still have a partial and one-dimensional perspective about climate change and its impact and emphasize that the favorable changes should mainly be produced using technocratic approaches. Such views are not in line with the system-of-systems (SOS) perspective, which tries to give an integrated and multidimensional perspective about the problems. In this regard, it is recommended that the policymakers should try to pay more attention to social and informative dimensions of climate change programs. This information can help the inexperienced farmers to adapt more rapidly to climate variability and change and raise their agricultural productivity.

The other point in applying climate change adaptation strategies is that vulnerability to climate change impacts significantly varies among different groups of

farmers and stakeholders. For example, Karimi et al. (2018a, b) mentioned that the effects of climate change on agriculture will be most severe for poor families and small-scale farmers with minimal adaptive capacity in different countries. Although policies that develop financial incentives may result in short-term gains, they can increase their vulnerability in the long term. Moreover, there is the possibility of public policies reducing the welfare of poor farmers, even as they benefit wealthier farmers with greater ability to respond effectively to climate change. Therefore, a set of actions will be required to relieve the expected severe pressures on poor farmers.

Although there are so many approaches for adaptation to climate change, it is worth mentioning that one of the main drawbacks of these approaches is lack of emphasis on adaptation feedback. Furthermore, according to experiences gained in developing and developed countries, adaptation to climate change depends, to a great extent, on conditions and characteristics of different areas. That is, climate, environmental, social, and political conditions play a key role in agricultural adaptation to climate change. This means that there is no one specific and fixed approach to climate change adaptation. There is no one-size-fits-all approach for adaptation to climate changes. However, being aware of the experiences of other countries (with similar climatic and geographical conditions) and adaptation strategies employed by them can definitely be useful for communities dealing with negative impacts of climate change.

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