Adaptation to Climate Change and Food Security: Case Study of India

التكيف مع تغير المناخ والأمن الغذائي: دراسة حالة الهند

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Abstract:
This study aimed at determining how certain farming adaptations to climate change can help ensure food security. The analytical and explanatory methods have been used to meet the main objective of this research work. Accordingly, the case of India has been studied and several insights have been obtained. The final conclusions demonstrated that food security could be maintained and improved through specific adjustments adopted by farmers in light of the new climatic patterns.

keyword: Climate change; Food security; Adaptation; India.
JEL classification code : XN1, XN2

ملخص:
تهدف هذه الدراسة إلى تحديد كيفية إسهام التكيّف مع ظاهرة تغيّر المناخ في تحقيق الأمن الغذائي؛ وقد تمّت الاستعانة بمناهج وصفية تحليلية لتحقيق الغرض الرئيسي من البحث؛ وبدراسة حالة الهند تمّ التوصّل إلى العديد من الرؤى؛ وقد أظهرت الاستنتاجات النهائية أن الرّهان على تعديلات وتكيفات محددّة اعتمدها المزارعون في ضوء أنماط مناخية مستجدّة من شأنه أن يساهم في الحفاظ على الأمن الغذائي ومن ثمّ تحسينه.

الكلمات المفتاحية : تغيّر المناخ؛ الأمن الغذائي ؛ التكيّف ؛ الهند.

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تصنيف JEL : XN1، XN2

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1. Introduction :

Climate change is increasingly becoming the concern of scores of governments, specialized institutions, relevant organizations, and civil societies around the globe due to its profound impact on people's well being and prosperity. Food security is doubtless one of the main sectors that are directly influenced by drastic changes in climate patterns. Accordingly, numerous research works have been conducted to examine the potential effects of such transformations on food security, and offered long-term solutions for current climate-related impediments. The present analytical study, which takes India as a case, is also inscribed within this releam. In effect, the main question of this study is : How can appropriate adaptation to climate change ensure food security ? This question generated more queries : What are the requirements of successful climate change adaptation for ensuring food security ? To what extent were the adaptation strategies adopted by the Indian government efficient ? To address such questions, this reaserch work adopted both the analytical and explanatory methods along with a few statistical procedures. The obtained results confirmed the aforementioned suppositions.

2. Understanding Adaptation and Food Security

This section presents a detailed description of the notions : *adaptation* and *food security* in light of the existing literature.

1.2. Adaptation Defined

The Intergovernmental panel on Climate Change (IPCC) describes adaptation as the process of adjusting the ecological, social or economic systems to become better suited to current or expected climatic stimuli and their potential effects (Leary & others, 2008, p6). In the same vein, the IPCC defines autonomous adaptation measures as "those that do not constitute a conscious response to climate stimuli, but result from changes to meet altered demands, objectives and expectations which, whilst not deliberately designed to cope with climate change, may lessen the consequences of that change." (Pittock, 2009, p194). In simpler terms, certain adjustments, which are made to

attain various objectives, could indirectly decrease the negative impact of climate change on people's welfare.

Adaptation, in the context of climate change, entails a series of steps that people or institutions may make as a reaction to actual changes in climate or in anticipation of probable ones to minimize adverse impacts or exploit the conveniences that climate change may yield. More precisely, adaptation to climate change can be either reactive or anticipatory. The latter refers to the measures implemented before impacts are observed, whereas reactive adaption is simply a reaction to certain effects produced by current changes in climate. According to a number of scholars (e.g. Parry & others, 2005), planned adaptation that is often attained through intended and calculated policy decisions can support both reactive and anticipatory adaptation.

The IPCC distiguishes several types of adaptation (Levina & Tirpak, 2005, p18) :

- Anticipatory adaptation : an adjustment which occurs before any climate change impacts are noticed/determined (also known as : *proactive adaptation*).

- Autonomous adaptation : a set of actions that are not intended to be a delibrate respone to climatic stimuli but are prompted by ecological changes in natural systems and by market or welfare changes in human systems. This type is also called *spontaneous adaptation*.

- Planned adaptation : a package of measures that are the outcome of a prepense policy decision. Such a decision is typically informed by an awareness that conditions have changed or are going to change, and that specific procedures are required to maintain, reach or return to a desired state.

- Private adaptation : refers to any adaption that is initiated and implemented by individuals, households or private companies. This type of adaptation is generally motivated by the doer's conscious reasoning and/or self-interest.

- Public adaptation : unlike the private adaption, this one is initiated and implemented by governments at all levels. Public adaptation is often intended to meet collective needs and expectations.

- Reactive adaptation : denotes the adjustments made after observing the impacts caused by climate change.

Adaptation is thought to have three different dimensions: (a) the subject of adaptation (who or what adapts), (b) the object of adaption (what they adapt to), (c) the manner of adaptation (how they adapt).

The subject of adaptation: in this dimension, adaptation occurs through alternations in ecological, social and or/ economic systems.

The object of adaptation: in the context of climate change, adaptive measures can be implemented either through changes in average conditions or alternations in variability of severe circumstances.

Modes, resources and results: experts suggested a number of criteria with which the various adaptation processes could be identified. (Bosello & others, 2012, p, p 10, 11).

A report issued by the Committee on Climate Change Approaches proposed a basic five-step plan for the implementation of adaptation procedures:

Step 1: share the knowledge and approaches that are relevant to adaptation, and consider the actual measures.

Step 2: determine the risks associated with climate change effects.

Step 3: encourage communication, and draw up adaptation schemes, initiatives, and measures.

Step 4: begin with the most attainable initiatives.

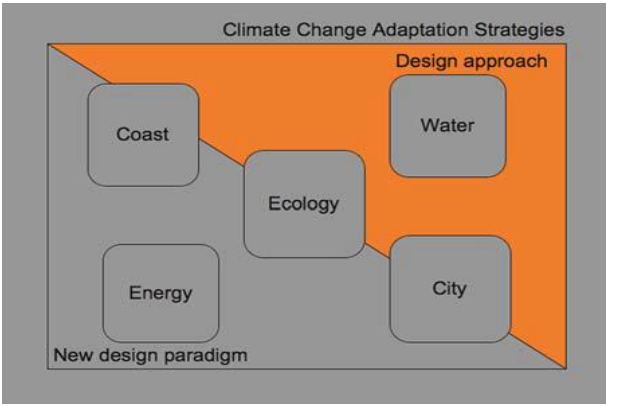
Step 5: strengthen risk analysis and adaptation proceedings by monitoring the different processes and changes in light of the latest

inputs available. (Committee on Approaches to climate change adaptation, 2010, p iv).

As explained above, the procedures aiming at implementing adaptation should not hinder any efforts made to maintain the balance of climate systems and other environmental aspects. Adaptation-related initiatives can be observed in wide range of sectors such as: "good water management –total support for prevention of catastrophic damage to agriculture – development of crops that have the ability to flourish in the new environment – reduced and climate smart inputs – providing ongoing accurate information – reducing deforestation – Control on urbanization – Enchancing the overall environment state by promoting biodiversity." (Sarkar & others, 2019, p, p 13, 14).

Although adaptation to climate change is clearly present in various governmental strategies and policies as well as in the international media, the necessary integrated designs for adapted spatial plans are hardly available; this could be because individuals, experts and decision makers, deem this kind of adaptation measures to be costly and complicated. (Roggema, 2009, p59). This might also explain that spatial-related adaptation plans are not a priority for the time being.

Fig.1: *Climate change adaptation strategies.*



Source : *Roggema, 2009, p59.*

Overall, people may not adapt al all of partially adapt due to a wide range of reasons. First, climate may be perceived, accurately or inaccurately dependindg on the context, to pose little or no risk in comparison to other factors ; therefore it may not receive enough attention. Second, there might be a lack of knowledge about the available options to reduce risks associated with climate change. Third, the means that would make implementation possible could be lacking. Forth, at times even the action or incation of others can create an obstacle. That is, some people or even governments may assume that minimizing their own risk is the responsibility of others. (Leary & others, 2008, p,p 10, 11). Hence, for adaption to be successful, many factors should be taken into consideration including people's (and governments') awareness and readiness to act responsibly and effectively.

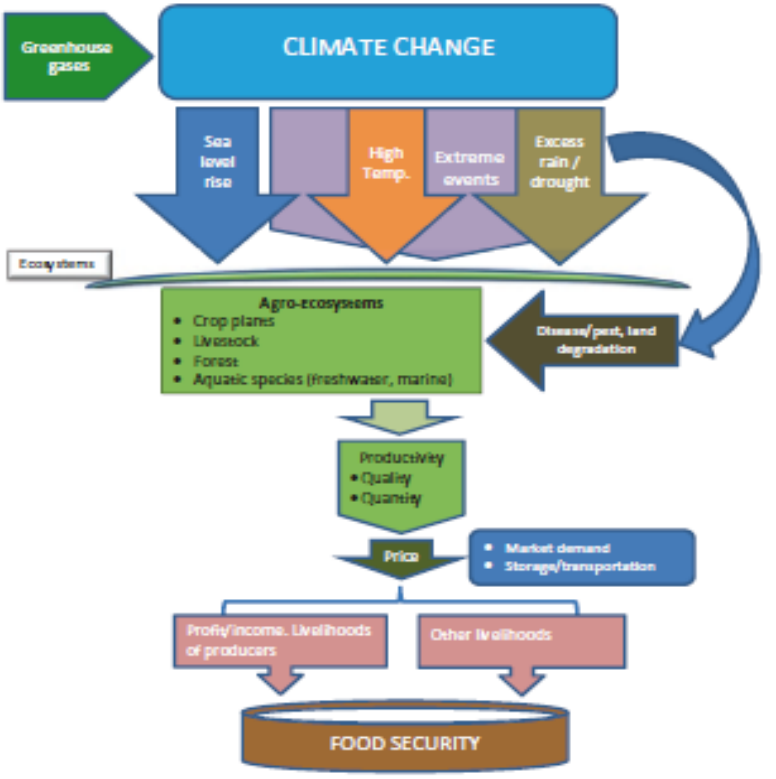
2.2. **Food Security and Climate change**

The Food and Agriculture Organization of the United Nations(FAO) describes the notion food security as " a situation that exists when all people at all times have physical, social, and economic access to sufficient, safe and nutritions food that meets their dietary needs and food preferences for an active and healthy life" (Maxwell & Smith, 1992). According to this definition, food security entails that every individual in a community has got enough food and nutrition that fits his health and life style. Furthermore, the aforestated definition implies that food security consists of three main components : food availability, food access, and food utilization. While *availability* refers to the physical presence of food, *access* denotes having the necessary means to acquire food through both production and purchase. *Utilization,* on the other hand, refers to the quality and usefulness of the provided food. (Lobell & Burke, 2010, p14).

Undoubtedly, the world poulation will not cease to grow and experts suggested that it is expected to rech 9,1 billion by 2050. For this reason, the total food production will have to be increased by 70-100% to make sure that all those people will be provided with suffisent and appropriate nutrition (Yadav & others, 2019, p3). And that is not an easy task to accomplish; It needs careful planning and great efforts from all concerned parties. For instance, over the last few years, the world has been witnessing heavy rainfalls and devastating floods, florest fires, huge occurrences, and a spread of new diseases. These unfortunate events have certainly jeopardized food security around the globe. In fact, indications of drastic environmental change have been detected repeatedly, and valid concerns have been raised accordingly. Agriculture came on top of the concerns as it is a vital sector. In nearly every developing country in Africa, Asia and Asia Pacific regions, about 70% of the population depends directly ,or at least indirectly, on the agricultural sector for its livelihood. And the biggest portion of those populations live in arid or semiarid regions, which are known for their highly volatile climate conditions. (Yadav & others, 2019, p1).

In addition to the issue of uncontrolled population growth, which is a major challenge that hinders the effort devoted to achieving global food security, the world is now facing another tough challenge widely known as *Climate Change* or *Globle Warming.* The latter has begun to pose a enourmous threat to our surrounding agro-ecosystems. As proposed by the IPCC 2014 report, the following figure explains how climate change could severely affect food security. (Sarkar & others, 2019, p4).

***Fig.2** : Climate change and Food Security*



***Source** : Sarkar & others, 2019, p4.*

The diagram illustrates how climate change (e.g. high temperature and sea level rise) could have a significant impact on "the availibilty of good quality water, habitats and species distribution, timing and length of growing season, distribution of agro-ecological zones, and ecosystem stresses" (FAO, 2012, p2). This means that all these areas and scopes are somehow associated when it comes to climatic threat, thus they could well influence each other. In light of this association, Downing (1996, p 125) explained that differences among countries, in terms of adaptation, are linked to crop production. He concluded that global warming has a direct impact on the current growing conditions. More precisely, high temperatures caused the

growing period to shorten at all locations that have been tested as a part of his experiment. Likewise, global warming is afecting agricultural productivity in higher latitude areas, raising yields of some crops (e.g. maize, wheat, cotton) ; whereas the production of other crops (sugar beets, barley) seems to decrease in lower-latitude regions. Based on aboriginal and local expertise, climate change is affecting food security in drylands, particularly those in Africa, and high mountain regions of Asia and South America. (IPCC, 2019, p5 –5).

Climate change is by no means confronting a fixed world which doesn't react to new significant circumstances. That is, human beings are adaptive of nature and would most probably find ways to adapt agriculture to the new climatic patterns (Lobell & Burke, 2010, p133). Building greenhouses is among those adaptation techniques. The greenhouse effect, also known as glass-houses, is a structure covered by either glass or plastic which permits regulated climatic conditions to happen inside. Gases with the capacity to absorb the radiant energy are called the greenhouse gases (GHG). Greenhouses are often exploited in the growing of flowers, vegetables, fruits, and tobacco throughout the year in the warm, agreeable climate. On this planet, there is a phenomenon called the 'natural greenhouse effect', or the Milankovich cycles. (Chen & others, 2017, p5). This universal phenomenon causes temperatures to rise, as if in a greenhouse, because thick layers of gases cover the planet and prevent the heat from escaping. This situation in turn result in a range of problems including a dangerous rise in global sea level.

3. Ensuring Food Security through Adaptation : A Case Study.

This section discusses the requirements for achieving food security by means of successful adaptation to changes in climate.

1.3. Farmer adaptation to climate change

Changes in climate conditions is thought to have a major influence on agricultural decision-making, thereby affecting what crops farmers grow, when and where they grow them. The ongoing changes in the planet's climate patterns exert a significant impact on global and regional food systems and on food security outcomes. (Lobell & Burke,

2010, p134). In this sense, the rate of food production in a given year is directly linked to the analysis and then attainment of specific meteorological variables (e.g. air pressure and temperature) that year.

Many scholars have conducted various research works in an attempt to assess the farmers' awareness about current and future changes in climate, alongside the available and possible options for adaptation to these changes. In addition, numerous studies investigated the potential factors influencing adaptation methods choice. A variety of evidences have been presented with regard to farmers' awareness about climate change in their areas ; for example, Ishaya reported a lack of awareness and knowledge among farmers in Jema'a, Nigeria. (Komba & Muchapondwa, 2015, p3). Observed farmer adaptations to changes in climate fit into two main categories : ex ante measures, for which action is taken in anticipation of a certain climate realization, and ex post procedures, which are performed after the event is realized. (Lobell & Burke, 2010, p135). According to various studies, there is often a gap, which could sometimes be a large one, between ex ante and ex post estimates of the environmental regulation costs, including both private and public-administrative costs. (Albanese and Ruiz, 2016, p343).

Ex ante adaptations to climate changes often centre around strategies of diversification, which aim to take advantage of the many effects which a given climate condition might have on different crops and activities in a given year. For instance, farmers growing rainfed crops in a drought – prone environment might want to change the setting of their farm plots to benefit from the high spatial variability of rainfall, grow a range of crops or crop varieties with distinct sensitivities to climate, or to diversify income sources into non-farm enterprises that are less sensitive to climate. Farmers also adopt various ex post strategies or decisions to reduce crop or welfare losses once climate events have been observed. Such strategies include drawing down cash reserves, storing grain, borrowing from banks or family members, selling assets such as livestock, or moving to other non-affected places to seek work and opportunities. Ex post adaptations can also take the form of changes to management after the start of the growing season,

such as replanting of faster-maturing varieties if early-season planting fails, or use irrigation where possible, if rainfall is not sufficient. (Lobell & Burke, 2010, p135).

Regrettably, not all strategies are accessible for all farmers, nor are the available strategies always efficient when it comes to buffering food security against changes in climate. In rich countries, farmers are protected against hunger when there is drought or other negative climate events. Unfortunately, in poor countries things are different and farmers risk to go hungry after climate-linked setbacks. Although both ex post and ex ante strategies can minimize climate-associated losses to a certain extent, the poorest households in particular are usually weak at shielding consumption from the effects of unfavorable climate conditions. In view of the existing literature, the voluntary food rationing, by reducing the number of meals and quantities eaten, is a common practice for many families. Individuals in rural areas tend to undertake a number of ex ante reactions to foreseen climatic and other shocks. These include income diversification, asset accumulation, and participation in social arrangements that provide assistance in hard times. The main goal of these strategies is to ensure rational consumption when production, or income, is not guaranteed. Conversely, in ex post some consumption will be ceased if the food security (sufficient production) of households is at risk (Downing, 1996, p617).

Farmers' awareness and understanding of climate risk are largely influenced by biophysical, socio-economic, political and psychological factors. (Luu and others, 2019, p2) :

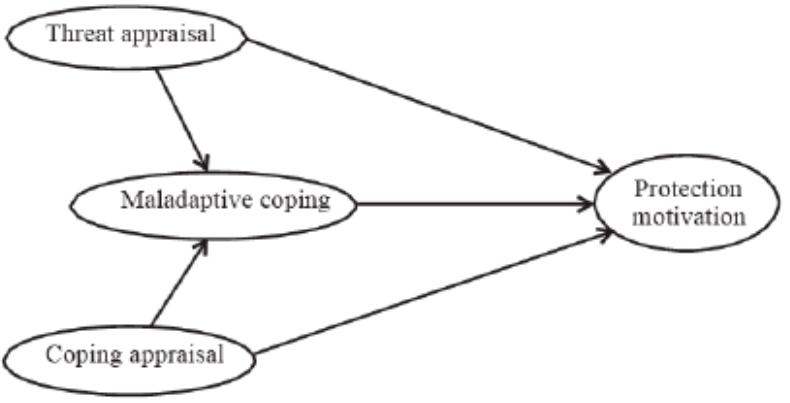
"Agricultural extension ; access to the national rural employment guarantee scheme, crop loss compensation, and access to informal credit are determinantsof climate change adptation of farms.

Psychological mechanisms ; are important to understand farmer's adaptation behaviour toward climate change, efficacy beliefs were the strongest predicator of behavioral intensions, which provide reliable informationfor local agricultural development.

Agricultural experience ; farm income, training, social capital, and communication to climate adaptation are listed as the most influential factors of climate change adaptation."

Over the last few years, 'The Protection Motivation Theory (PMT)' has begun to appear in research work that investigated environmental risks, natural setbacks, and climate change, PMT focuses on four main aspects of the cognitive mediating processes : threat appraisal, coping appraisal, maladaptive coping, and protecting motivation. (Luu and others, 2019, p3).

Fig.3 *: Path diagram of core elements in the cognitive mediating of PMT*



Source *: Luu and others, 2019, p4.*

2.3. Climate change adaptation and food security in India

Agriculture in India is characterized by a variety of crops, most especially rice, wheat and millet. In India, most crops are grown in rather hot surroundings. Spring and summer temperatures usually go above $4O^0$ C even in the current climate. Therefore, crops are likely to be more sensitive to heat. In fact, a survey on rice crop modeling studies suggested that even with CO_2 fertilizaton, warming above 2^0C

is expected to reduce rice yields in India. (Lobell & Burke, 2010, p184). In addition to the fact that India has the highest population of undernourished individuals worldwide, food security in India seemed particularly vulnerable to climate change. That's why, India has quickly made major decisions in an attempt to boost food production. As a result, India has achieved self-sufficiently in food production, and began to export food to several countries. "However, climate change has emerged as a major threat to India's hard-earned success." The majority of Indians rely on climate-sensitive sectors such as agriculture, forestry, and fishing, and therefore the lives of a huge number of people are jeopardized. In fact, India has already suffered from the adverse effects of climate change on food production, transportation, storage and distribution. (Sarkar & others, 2019, p497).

India adopted the National Agroforestry Policy in 2014 to promote and expand tree plantation in an integrated manner with crops and livestock to boost productivity. The policy seeks also to improve employment, incomes, and livelihoods, and thus protect and maintain the stability of ecosystems to encourage resilient cropping and farming systems. The latter is likely to reduce risks during extreme climatic events. The National action Plan on climate change highlighted the following points : - Adaptation for dryland agriculture – Managing risks due to extreme climatic events – Knowledge dissemination and translation – The development and utilization of climate – smart Biotechnology. (Sarkar & others, 2019, p505).

India's National Action Plan on Climate Chenge (NAPCC) decided to implement an action plan through a set of eight national missions coverting the sectors of water, energy, habitats and agriculture. More missions are on the anvil-focusing on coastal zones, health and waste management. A major issue within the action plans and missions highlighted by critical studies is the negligence of institutional problems, namely the need for accurate institutional design, and the imperative to ensure cross-scale and cross - agency institutional collaborations (Venkataraman & others, 2019, p260).

'Climate-smart agriculture (CSA)' is deemed a pragmatic approach that helps to guide actions required for the transformation and

reorientation of agricultural systems to boost development and ensure food security in unusual climate conditions. According to FAO, the CSA has three major goals : (a) sustainbly achieving agricultural productivity and income ; (b) adapting an building resilience to climate change ; (c) reducing or removing greenhouse gas emmissions ; where feasible. (Sarkar & others, 2019, p,p 497, 505).

The Indian government has started to notice the advantages of watershed management for a more long-term perspective of confronting problems posed by the climate. Successful implementation of the 'Integrated Watershed Management Program (IWMP)' can assist with the restoration of ecological balance, increase in the productivity levels in rain –fed areas, and enhance living conditions in rural areas. The government of India's Ministry of Rural Devlopment implemented three watershed programs : - Integrated Wastelands Development Programme (IWDP) – Drought Prone Areas Programme (DPAP) – Desert Development Programme (DDP). (Barua and Others, 2019, p153).

Although there is a surplus in food-grains stocks, a considerable number of people around the world are struggling to ensure their daily meals. In India, for instance, around 30 million individuals have been identified with hunger problems since the mid 1990s and 40% of the children suffered from underweight issues. Statistics show that in india, roughly 320 people sleep hungry every night. (Jaswal, 2014, p, p, 95, 99). In an attempt to eliminate the supply-side constraints in food security, the following plan have been proposed : (Singh, 2016, p, p, 10, 11)

- Cost-effective supply of food to the consumers is also significant and should be considered ; food producers tend to focus more on the productions costs. Therefore, existing delivery techniques and procedures needs to be revised and improved.

- Agriculture innovation systems need to be supported by promoting investments in technology transfer and farm extension services, rural infrastructure, post harvesting R&D to decrease waste, etc.

- Food security is tightly related to water availability and usage. In fact , the demand on water is likely to increase beyond the agricultural exploitation, including household, industry and environmental flows. Redusing water consumption is, hence, a necessity in agriculture. This could be achieved through better technologies, management plans and change in cropping procedures.

- New technologies such as laser land levelling, Zero tillage and sprinkler and drip irrigation, etc, could be encouraged to enhance the irrigation efficiency.

- Motivate corporate sector to direct a part of its Corporate Social responsibility (CSR) funds toward training farmers and developing their skills to push them to adopt water efficient, cost-effective and sustainable farming system, including organic farming.

- Food absorption could be improved through generous investments in drinking water, sanitation, and similar public services.

4. Study Methodology :

This study relied heavily on the analytical and explanatory methods which entails collecting, organizing, alalysing, and describing data in an attempt to explain or highlight a state of affaires. In the analytical method, the researcher starts from the facts available and use them to arrive at significant evaluations and understanding of a certain phenomenon or study cases. Furthermore, the study employed a few statistical procedures to look deep into the issue of guaranteeing food security in light of the current climate change patterns. The choice of the aforementioned methods is motivated by the nature of the topic (i.e., climate change and food security) and the existing literature as well as the feasibility of research in general.

5. Study Results :

The results yielded from this study could be summarized in five main points. First, important measures, such as farming adaptations, should be taken to ensure food security. In simpler terms, the farmers are advised to ajust their methods and techniques to the new climatic

circumstances to increase food production. Second, initiative and plans should be monitored and supported. The actions and adaptation plans are more effective when they are used on a large scale and in an organized manner (e.g. mass tree-planting plans). Third, the world should give more attention to agriculture which is a vital sector. For instance, agricultural technology could provide the humanity with solutions to meet today's challenges. It has become evident that traditional farming techniques, which are used in scores of countries, are unable to cope with the actual circumstances and needs. Forth, there should be a continuous awareness and promoting of climate-friendly ways of life. People should be made aware of the danger that climate change pose as well as the fact that they can help by changing some of their habits and preferences such as using recycled products and environment-supportive materials.

6. Conclusion :

Climate change is a serious challenge that should not be neglected as it poses grave threat to the welfare of human beings. Thus, effective adaptation to both the current and anticipated changes in climate patterns is a pressing necessity. Likewise, food security is a sensitive issue which should be well maintained in both the short- and long-terms. There are, as the existing literature shows, many ways in which this could be done. And all the concerned parties are urged to join efforts to keep this world healthy, safe, and balanced.

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