



ISSN: 2230-9926

Available online at <http://www.journalijdr.com>

IJDR

**International Journal of
DEVELOPMENT RESEARCH**

International Journal of Development Research
Vol. 4, Issue, 2, pp. 359-365, February, 2014

Full Length Research Article

CLIMATE CHANGE AND FOOD SECURITY IN INDIA: CONTEMPORARY CONCERN AND ISSUES

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ARTICLE INFO

Article History:

Received 13th November, 2013
Received in revised form
07th December, 2013
Accepted 08th January, 2014
Published online 21st February, 2014

Key words:

Food availability,
Accessibility,
Utilization and
Stabilization

ABSTRACT

Climate change and its impact is a matter of great concern among all countries of the world because it has the potential to make vulnerable life on the earth. Therefore an attempt has been made here to examine the impact of climate change on the food security of India with special reference to the agro-climatic regions. The study revealed that climate change can adversely affect the all four dimensions of food security i.e. food availability, accessibility, utilization and stabilization. There is a great deal of uncertainty regarding climate change, but there are some certainties. The prospects of Indian food security under the upcoming climate change will depend a numbers of immediate measure i.e. to reduce the vulnerability of food system to climate change and other global environmental changes, which has started looming large the very existence of human kind.

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INTRODUCTION

Change is a law of nature, every phenomenon in this universe is dynamic and climate is not an exception. There are always two kinds of processes behind the climate change one is natural and other is human being induced. Anthropogenic activities are more responsible for climate change. Climate change has become one of the most important global environmental challenges of 21st century facing humanity with implications for food production and food sustainability. It has been at the centre of scientific and political debate in recent years, today, more than at any time in the past there is an almost unanimous consensus among scientists, politician, policy-makers, administrators and the common people alike that climate has changed and that it is still changing (IPCC, 2007). However, scientist have become more confident that greenhouse gases will lead to a rise in global temperature (Houghton et al 1996). In the developing countries have grown increasingly concerned about the economic impact of climate change on agriculture (Watson et al, 1996). Most of the studies to date has focused on the developed countries (Riely, 1995), very few study has focused on developing countries specifically India. The concept of food security is not new for the researchers, prediction of food security outcomes have

been a part of the policy landscape since Malthus 'An Essay on the principal of population' of 1798 (Mathus, 2003). Food security refers to the availability of food and one's access to it. A household is considered food secure when its occupants do not live in hunger or fear of starvation. Food security exists when all people at all times have physical or economic access to sufficient safe and nutrition's food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). It has four basic components availability, accessibility, utilization and stabilization. The four components of food security are availability a function of production, accessibility is related to purchasing power, utilization is determined by the availability of minimum basic needs i.e. safe drinking water, primary health care, primary education, proper housing facilities, environmental hygiene fourth one stabilization is influenced by the extent of attention given to the sustainability of the system. Therefore, concept of food security is very complex and multidimensional and it cannot be limited to its specific divisions. So it must include the issue of food production, distribution, quality of food, capability of purchasing and sustainability of this entire process.

Climate Change and Food Security

Food security is both directly and indirectly linked with climate change. Any alteration in the climate parameters such

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as temperature and humidity which determines the growth of crop will have direct impact on the quality of the food produced. Indirect linkage pertains to catastrophic events such as floods and drought which are projected to multiply as a consequence of climate change leading to huge crop loss and leaving large patches of arable land unfit for cultivation and hence, threatening food security (Chaudhary and Aggarwal, 2007). Many studies have been carried out to examine the impact of climate change on the agriculture; some of the very significant are (Rosenzweig 1985, Sinha and Swaminathan 1991, Rathore et al 2001 and Blanc 2012). These studies shows that climate change may affect food system in several ways ranging from crop production to changes in markets, food price and supply chain infrastructure. Changing pattern of rainfall in semi-arid and sub-humid region which, may be translated to a decline in rain-fed cereal production, thereby challenging the livelihoods of billion of people due to global temperature changes as well as the rainfall uncertainty. Climate change will affect food security through its impacts on all components of global, national and local food production systems which is projected to affect all four dimensions of food security namely food availability, access to food, food utilization and food sustainability (Ranuzzi and Srivastava, 2012). In the other words with many of the resources needed for sustainable food security already stretched, the food security challenges are huge. Climate change will make it even harder to overcome them, as it reduces the productivity of the majority of existing food systems and harms the livelihoods of those already vulnerable to food insecurity (FAO, 2008).

Climate Change and Food Security in India

India has many reasons to be concerned about climate change, because a majority of population depends on climate sensitive sector i.e. agriculture, forestry and fishing for livelihood. The existing problem of food security in our country, if not addressed in time, will become more acute due to change in the climate. It will become more difficult to ensure food security under the changing climate for country like India where more than one third of the population is estimated to be absolutely poor and one half of all children are malnourished in one way or another (Dev and Sharma, 2010). To examine the impact of climate change on Indian agriculture sector is quite complex as several factors are concerned in this phenomena. For the detail discussion about impact of climate change on food security we have taken the four components of food security and discuss the impact of climate change on these components in the Indian context.

Climate Change and Food Production

The evaluation of climate change impacts on agricultural production, food supply and agriculture based livelihoods must take into account the characteristics of the agro-ecosystem where particular climate-induced changes in biochemical processes are occurring, in order to determine the extent to which such changes will be positive, negative or neutral in their effects (FAO-2008 P. 21) greenhouse fertilization effect will produce local beneficial effects where higher level of atmospheric CO₂ stimulate plant growth. This is expected to occur primarily in temperate zones with yield expected to increase by 10 to 25%. (IPCC, 2007c) These effects are not likely to influence projections of world food

supply, (Tubiello *et al.*, 2007). But in India tropical type of climatic condition prevails so here most probably the greenhouse fertilization will have negative impacts. The impact of mean temperature increase will be experienced differentially, depending on location (Ieff, Romand Kutty and Faley, 2004) for example, Moderate warming (increase of 1 to 3°C in mean temperature is expected to benefit crop and pasture yields in temperate regions while in tropical and seasonally dry regions like India, it is likely to have negative impacts particularly for cereal crops. Warming of more than 3°C is expected to have negative effects on production in all regions (IPCC, 2007c). It is also evident from the Fig. No 1 that how the global warming will affect the world. For climate variables such as rainfall, soil moisture and radiation, crops have thresholds beyond which growth and yield are compromised (Porter and Semenov, 2005). For example, cereals and fruit tree yields can be damaged by a few days of temperatures above or below a certain threshold (Wheeler *et al.*, 2000).

An average of 500 weather-related disasters are now taking place each year compared with 120 in the 1980s; the number of floods has increased six fold over the same period (Oxfam 2007). Increased intensity and frequency of storms, altered hydrological cycles, and precipitation variance in India also have long term implications on the viability of current and future food availability. Constraints on water availability are a growing concern, which the problem of climate change will further exacerbate. Conflicts over water resources will have implications for both food production and people's access to food in conflict zones (Gleick, 1993). Even today in India we can see many cases of water dispute which are inter-state and intra-state but in future because of climate change the scarcity of water will be further increased and intensity of these types of dispute will be more. All these factors will further compound the problem of food availability. Prolonged and repeated droughts can cause loss of productive assets, which undermines the sustainability of livelihood systems based on rain fed agriculture like India where approximately 70% cultivated land is practiced under the system of dry land farming. Drought and deforestation can increase fire danger, with consequent loss of the vegetative cover needed for grazing and fulured.

Climate change and Storage, processing and distribution of food grain

Food production varies spatially, so food needs to be distributed between regions. The major agricultural production regions are characterized by relatively stable climatic conditions but many food-insecure regions have highly variable climates. The main grain production regions have a largely continental climate, with dry or at least cold weather conditions during harvest time, which allows the bulk handling of harvested grain without special infrastructure for protection or immediate treatment. Depending on the prevailing temperature regime, however, a change in climatic conditions through increased temperatures or unstable, moist weather conditions could result in grain being harvested with more than the 12 to 14% moisture required for stable storage. Because of the amounts of grain and general lack of drying facilities in these regions, this would create hazards for food safety, or even cause complete crop losses, resulting from

contamination with microorganisms and their metabolic products. It would lead to a rise in food prices if stockiest have to invest in new storage technologies to avoid the problem (FAO, 2008). Distribution depends on the reliability of import capacity, the presence of food stocks and when necessary-access to food aid (Maxwell and Slater, 2003). These factors in turn often depend on the ability to store food. Storage is affected by strategies at the national level and physical infrastructure at the local level. Transport infrastructure limits food distribution in developing country like India. Where infrastructure is affected by climate, through either heat stress on roads or increased frequency of flood events that destroy infrastructure, there are impacts on food distribution, influencing people access to markets to sell or purchase food (Abdulai and Crole Rees, 2001).

Climate change on food access

Food is allocated through market and non-market distribution mechanisms. Factors that determine whether people will have access to sufficient food through markets are considered in the affordability. These factors include income-generating capacity, amount of remuneration received for products and goods sold or labor and services rendered and the ratio of the cost of a minimum daily food basket to the average daily income (FAO, 2008). Non market mechanisms include production for own consumption, food preparation and allocation practices within the household, and public food distribution schemes. The approximately 70% population of India live in rural areas. For rural India where people who produce a substantial part of their own food, climate change impacts on food products may reduce availability to the point that allocation choices have to be made within the household. A family might reduce the daily amount of food consumed equally among all household members, or allocate food preferably to certain members often the able-bodied male-adults who are assumed to need it the most to stay fit or continue working to maintain the family. Non-farming low income rural and urban households whose incomes fall below the poverty line because of climate change impacts will face similar choices.

Allocation issues resulting from climate change are therefore likely to become more significant in urban areas over time. Urban agriculture has a limited ability to contribute to the welfare of poor people in India because the bulk of their staple food requirements still need to be transported from rural areas (Ellin and Sumberg, 1998). In many countries the ratio of a minimum daily food basket to the average daily income used as a measure of poverty (World Bank Poverty Net, 2008) when this ratio falls below a certain threshold, it signifies, that food is affordable and people are not impoverished; when it exceeds the established threshold, food is not affordable and people are having difficulties in obtaining enough to eat. This criterion is an indicator of chronic poverty, and can also be used to determine when people have fallen into temporary food insecurity. Owing to reduced food supply and increased prices to a sudden fall in household income or to both. Most food is not produced by individual households but acquired through buying, trading and borrowing. Climate impacts on income-earning may affect the availability of certain food products, which may influence their price. High prices may make certain foods unaffordable and can have an impact on

individual's nutrition and health. Changes in the demand for seasonal agricultural labor caused by changes in production practices in response to climate change, can affect income-generating capacity positively or negatively. Mechanization may decrease the need for seasonal labor in many places, and labor demands are often reduced when crops fail, mostly owing to such factors as drought, flood frost or pest. Out breaks which can be influenced by climate (FAO, 2008). Food preferences determine the kinds of food households will attempt to obtain. Changing climatic conditions may affect both the physical and the economic availability of certain preferred food items, which might make it impossible to meet some preferences. Change in availability and relative prices for major food items may result in people either changing their food basket, or spending a greater percentage of their income on food when prices of preferred food items increase.

Climate change on food utilization

Food insecurity is usually associated with malnutrition, because the dieting patterns of people who are unable to satisfy all of their nutritional requirements don't consist of nutritious food grains. Declines in the availability of mild foods and limits on small-scale horticultural production due to scarcity of water or labor resulting from climate change could affect nutritional status adversely. In general, however, the main impact of climate change on nutrition is likely to be felt indirectly, through its effects on income and capacity to purchase in order to diversify their food basket. In India climate change will cause new patterns of pests and diseases to emerge, affecting plants, animals and humans, and posing new risk for food security, food safety and human health. Increased incidence of water-borne diseases in food-prone areas like U.P., Bengal, Orissa, Bihar, Andhra Pradesh and Maharashtra etc; changes in vectors for climate responsive pests and diseases, and emergence of new diseases could affect both the food chain and peoples physiological capacity to obtain necessary nutrients from the foods consumed. These will expose crops, livestock, fish and humans to new risks to which they have not yet adopted. They will also place new pressures on care giver within the home. Malaria in particular is expected to change its distribution in a result of climate change (IPCC, 2007a). In coastal area of India more people may be exposed to vector-and water-borne diseases through flooding linked to sea-level rise. Food safety may be compromised in various ways. Increasing temperature may cause food quality to deteriorate, unless there is increased investment in cooling and refrigeration processing of perishable foods to extend their shelf-life.

Climate change on food sustainability

Many crops have annual cycles and yields which fluctuate with climate variability, particularly rainfall and temperature. Maintaining the continuity of food supply when the production process is seasonal in nature is a therefore challenging task. Droughts and floods are a particular threat to food stability and could bring about both chronic and transitory food insecurity. As we know India is a country which is more prone to drought and floods. Both are expected to become-more frequent, more intense in India and less predictable as a consequence of climate change. In rural areas which depend mostly on rain fed agriculture has the 70% of the total population of India which

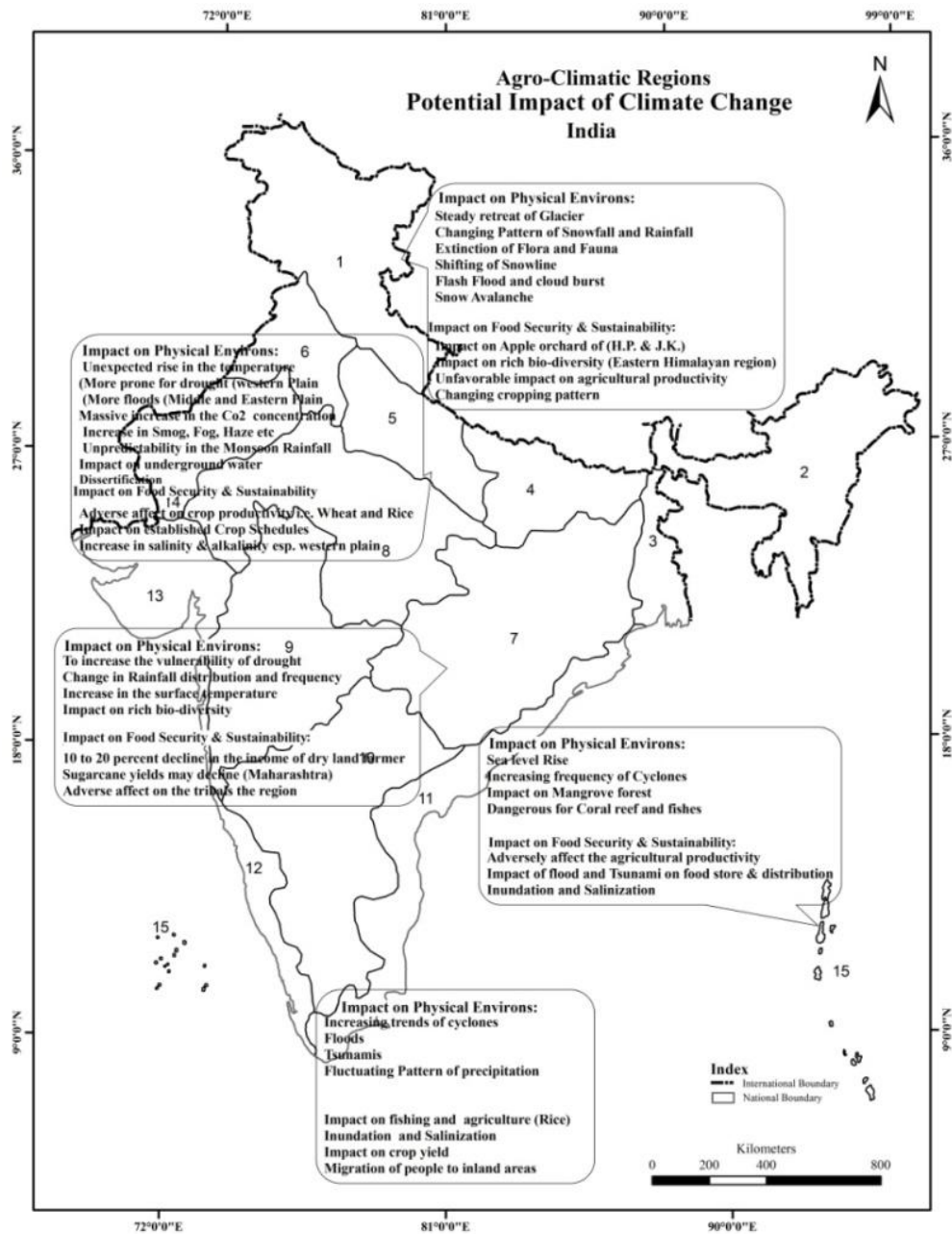


Fig. No 1

depends on the local food supply. Changes in the amount and timing of rainfall within the season and an increase in weather variability are likely to aggravate the precariousness of local food system. Increasing instability of supply, attributable to the consequences of climate change, will most likely lead to increases in the frequency and magnitude of food emergencies with which the global food system is ill-equipped to cope. Climate change might exacerbate conflict in numerous ways, although links between climate change and conflict should be presented with care. Increasing incidence of drought may force people to migrate from one area to another, giving rise to conflict over the access to resources in the receiving area. Resource scarcity can also trigger conflict and which could be driven by the global environmental change.

Impact of climate change Agro-climatic regions in India

Many agricultural development projects in various parts of the worlds failed to link agro-climatic condition properly. FAO defined an agro-climate zone as a land unit delineated in terms

of major climate and growing period, which is climatically suitable for certain range of crops and cultivars. The main objective was to integrate plans of the agro-climatic regions with the state and national plans to enable policy development based on techno-agro-climatic considerations. In the agro-climatic regional planning, further sub-regionalization was possible based on agro-ecological parameters. Agro-climatic zone is the concept of analyzing the geographical nature of a region from the context of its agricultural prospective. If the agricultural practices of different regions are conducted according to the agro-climatic conditions then they would be more sustainable. Genetic diversity and bio-diversity of a particular agro-climatic zone should be factored in before framing the agricultural policy for a particular zone. It is evident from the (Fig No 1) that Indian agro-climatic regions are highly vulnerable for the hazardous impact of climate change. There are many evidences that glaciers in Himalayas are retreating at a rapid pace. The Himalayan region is known as storehouse of water and spread over the states like J&K,

H.P and Uttarakhand in western Himalayan region and north eastern states. The existing problems of the region are severe soil erosion, degradation due to heavy rainfall and deforestation, poor road, poor input delivery and inadequate communication, infrastructure and marketing, shifting cultivation and non-availability of electricity. These all problems are directly or indirectly affecting the food availability. It is also evident from the (fig. no 1) that upcoming conditions of this region will more severe in context of climate change and food security. In this region there is need of rational use of land resources, adoption of integrated farming system with emphasis on temperature fruits and vegetable crops, adoption of micro-irrigation methods, and need of developed marketing infrastructure. The great plain is known as the bread basket of India because of rich water and fertile soil resources. In this agro-climatic zone of Punjab, Haryana and Western UP are practicing a water intensive mode of agriculture which is enabled by the use of subsidized electricity. Excessive use of fertilizers and irrigation has been eroding natural sustainability of the agricultural prospective of these regions. Other main problem of the region is flood, water logging, improper drainage, salinity/alkalinity, arsenic contamination high population growth, ground water depletion, micronutrient deficiency, which can affect the future of food security of India.

But unsteadied of this entire problem this region has huge potentiality of agriculture production. This potentiality can be beneficial for us if we harnessed it with the concept of agriculture sustainability. There is need of many development priorities like soil and water shed development, need of integrated plant nutrition system, adoption of zero tillage/fanon irrigated raised bed (FIRB) technology in rice-wheat cropping system areas, reclamation of waste lands and soil salinity, alkalinity through the use of pyrites and gypsum. Introduction of pulse crop/green manure in the crop sequence as a rule to reliance soil fatigue in rice-rice-wheat cropping sequence. Inter cropping in rain fed areas, promotion of Bt. Cotton, and use of organic manure and agricultural waste to improve soil health. The Great Indian peninsular plateau, also known as the store house of minerals in India, is a vast plateau, comprising most of the southern part of the country. This region has huge potential of dry land farming. Main problems of this region which are result of its geographical location and some are the origin of current agriculture practices. These are moisture stress drought and soil acidity, iron-toxicity, non-availability. Soil crusting is cracking, low productivity, absence of irrigation facilities, soil salinity/alkalinity.

Beside these problems in this region is rich in land and water resources. But for the food security of Indian context this region can play very important role because of huge potential of crops, fruits and livestock of this region. Another example is the Western Maharashtra where sugarcane production is very intensive but also climatically this zone is very arid and to practice water intensive agriculture in this zone cannot be sustainable for the long term sustainability of the agriculture. While crops like Jowar, Bajara Maize and Ragi which are suitable for arid agro climatic regions of India are not properly incentivized by the policy formulation in India. If the production of these crops is properly incentivized by the policy formulators in their respective agro-climatic zones than

India can develop an agro-climatically sustainable food security policy. Creation additional irrigation potential to harness full potential of agriculture, water harvesting/conservation through adoption of cultural practices like ridge and furrow planting, inter-cropping of legumes in uplands, planting against slope in undulating terrain/hilly tract. Inter-culture in between rows to create soil mulch and vegetative/bio-mulching. There are needs to productive use of barren and un-cultivated lands, cultivation of waste and permanent fallows through a forestation. There is need to diversification of sugarcane area by cotton and adoption of integrated farming system. Encouragement of hybrids of maize, cotton, sorghum, sunflower, jatropha and adoption of improved rain fed farming system. The coastal region also has many problems like other region of India mainly there are poor water management, poor nutritional status of soils, saline lands, aridity, frequent drought, moisture stress poor soil, beside these problem the region has rich water resources which can play a significant role in the agricultural productivity. This increased agricultural productivity can gave important contribution for the food security of India.

The coastal plain of India can play very important role to reduce the upcoming impact of climate change on the food security of India. Endorsement of integrated water management in dry areas with greater emphasis on rain water harvesting, water harvesting/conservation through adoption of cultural practices like bed furrow in deep black cotton uplands and in deep black cotton uplands and flat sowing or ridging later in light soil. There is need made Restriction on overdrawing of ground water in semi-arid and arid region through regulatory measures. Promotion of fodder development programme to support livestock population. We have to development of inland and brackish water fisheries through adoption of intensive fisheries production technology.

Island of India is regions can adversely affect by rise of the sea level. Rich water resources with relatively poor land and fragile ecosystem. Problems mainly are soil salinity and acidity. In this region main existing problems are frequent cyclones, poor and communication infrastructure, removal/leaching of salts, construction of dykes to cheek ingressions of sea water on the surface and in low soil profile and plantation mangroves. There are needs to promotion of the cultivation of plantation crops, mari-culture of oysters and mussels, ornamental fish breeding and culture and diversified fishing activity.

In addition there are several zone specific priorities which need to be looked into for the food security of India. Every agro-climatic region of India has their own importance in term of soil, water, climatic condition. So there is a need of region specific planning of agriculture, development should base on the concept of agricultural sustainability. Well planned agro-climatic region can play very important role in India for sought out the problem of food insecurity agricultural potentiality of agro-climatic region and problems of these region which are natural or caused by current agricultural practice.

Conclusion & Suggestions

There is a great deal of uncertainty regarding climate change, but there are some certainties. The prospects of Indian food

security under the upcoming climate change will depend a numbers of immediate measure i.e. to reduce the vulnerability of food system to climate change and other global environmental changes, which has started looming large the very existence of human kind. A multifaceted approach of adoption in terms of increasing food production, improving food distribution and increasing economic access to food as well as different mitigation options for reduction of green house gases needs to be adopted. Adaptation to climate change impacts should not be approached as separate activity, isolated from other environmental and socio-economic concerns that also impact on the development opportunity of poor people (OECD, 2003).

The climate change calamity can then become a blessing in terms of reorientation of our agricultural research and development strategies based on the principles of ecology economics, equity, employment and energy security. The path ways to an evergreen revolution are organic farming and green agriculture (Swaminathan 2008). Diversification of agriculture away from staple crops to horticulture, floriculture and commercial crops can also increase the income of small farm holders (Thakur and Chand, 2013). Approaches and the implications of each for protecting food security in the face of climate change are explored it may be reaching vulnerable rural people with useful information related to climate change. There are need to maintain up-to date agro-metrological data and to develop some methods and tools for assessing extreme weather impacts and guiding adaptation. We have to protect our existing livelihood system and diversify the sources of food and income. Most important things are to manage agriculture; land and water with more efficiently. There are need to understand the linkages among climate change, energy security, food security and Improve household energy security and food security simultaneously.

REFERENCES

- Abdulai, A. & Crole Rees 2001. Constraints to income diversification strategies: Evidence from Southern Mali: *Food Policy*, 26(4); 437-452.
- Blanc, E. 2012. The impact of climate change on crop yields in sub-Saharan Africa, *Earth Environment Science* 1:1-13.
- Chaudhary, A., Aggarwal, P.K. 2007. "Climate Change and Food Security in India", National workshop on Climate Change and its impacts on Health, 26-27th Nov. 2007.
- Dev, S. M. and Sharma, A.N. 2010. Food security in India: performance challenges and polices. Oxfam Indian working papers series: 1.
- DuToit, A. & Ziervogel, G. 2004. Vulnerability and food insecurity: Background concept for informing the development of a national FIVIMS for South Africa. Available at: www.agis.agric.za.
- Ellis, F. & Sunberg J. 1998. Food production, urban area and policy responses. *World Development*, 26(2):213-225.
- FAO 1996. Rome declaration and world food summit plan of action. Rome, Available at: www.fao.org.
- FAO 2008. Climate change and Food security: A frame-work document, p.21, Rome.
- FAO 2008. Climate change and food security: A framework document, Food and Agriculture Organization. United Nation, Rome.
- Gleick P.H. 1993. Water in crisis: A guide to the world's fresh water resources. New York, Oxford University Press.
- Houghton, J.T., L.M. Filho, B. Callander, N. Harris, A., Kattemberg and K. Maskell 1996 (eds), Climate change 1995: The science of Climate Change, U.K., Cambridge University Press for IPCC.
- IPCC 2003a. Climate change 2003-Impacts, adaption and vulnerability contribution of working group-2 the forth assessment report of IPCC, Cambridge, U.K. Cambridge University Press.
- IPCC 2007c. Climate change 2007 the physical science basis. Contribution of Working Group ii to the Fourth Assessment Report of IPCC. Cambridge University Press.
- IPCC. 2001. Climate change 2001 the scientific basis contribution of working group 1 to the third assessment report of the "Inter governmental panel on climate change ed. Houghton, J. et al. Cambridge University Press.
- Left, B., Ramankutty, N. & Faley, J. 2004. Geographical distribution of major crops across the World. Article No.GB1009 in *Global Biogeochemical Cycles*, 18(1).
- Maxwell, S.U. Slater, 2003. Food policy old and new. *Development Policy Review*, 25(5-6): pp 531-553.
- NATCOM 2004. India's Initial National Communication to the United Nations Frameworks Convection on Climate Change. National Communication Project, Ministry of Environment and Forests, Govt. of India.
- OECD 2003. "Poverty and Climate Change Reducing Vulnerability of the poor through adaptation." Paris; OECD.
- Oxfam 2007. Report cited in BBC online weather disasters getting worse. 25 November 2007: Available at www.bbc.com.UK.
- Parter, J.R. & Semenov, M.A. 2005. Crop responses to climate variation. *Philosophical Transactions of the Royal Society B: Biological Science*, 360:2021-2035.
- Rathore, L.S., Singh, K.K., Sassendran, S.A. and Barla A.K. 2001. Modeling the climate change on the rice production in India. *Mausam* 52 (1): 263-274.
- Reily, J. 1995. Climate change and global agriculture: recent finding and Issues. *American Journal of Agricultural Economics*, 77 (72):7-33.
- Rosenzweig, C. 1985. Potential CO₂ induced effect on North America wheat producing regions 7: 367-389.
- Satyasia, K.J.S. & Viswanathan R.V. 1996. Diversification of Indian agriculture and Food Security in *Journal of Agriculture Economic*, Vol. 51, No. 4, Oct-Dec. 1996.
- Singh, Punjab 2006. Agro-climatic zonal planning including agriculture development in north-eastern India." Final Report, Vol.1, pp. 21 to 45.
- Sinha, S.K. and Swaminathan, M.S. 1991. Deforestation, climate change and sustainable nutrients security. *Climate Change* 16: 13-45.
- Surjit S.Bhalla 2011. Who are real cronies! *Indian Express*, 29 Oct., 2011.
- Swaminathan, M.S. 2008. "Freedom from hunger and rural knowledge revolution." *Yojana*, July 2008, pp. 5-7.
- Tubiello, F.N., Amthor, J.A. Boote, K. Donatelli, M. Easterling, W.E. Fisher, G. Gifford, R. Howder, M. Reilly, J. Rosenzweig 2007. Crop response to elevated co₂ and world food supply. *European Journal of Agronomy*, 26:215-228.
- Watson, R., M. Zinyowera, R. Moss and D.Dokken 1996. (eds.) Climate change 1995: Impact, adaptation and

- mitigations of climate change: Scientific-technical analysis. U.K., Cambridge University Press for IPCC.
- Wheeler, T.R., Crauford, P.Q., Ellis, R.H., Porter, J.R. & Vara Prasad, P.V. 2000. Temperature variability and the yield of Annual Crops. *Agriculture, Ecosystems and Environment*, 82:159-167.
- World Bank Poverty Net 2008. Measuring Poverty. Available at: <http://go.worldbank.org>
- World Health Organization and Agriculture Organization of the United Nations guidelines on food fortification with micronutrients, 2006 cited on Oct.20, 2011.
- Malthus, T.R. 2003. *An Essay on the principle of population*, Norton, New York.
- Dev, S.M. and Sharma, A.N. 2010. *The food security of India: Performance, Challenges and Policies*. Oxfam India working papers series.
- Ranuzzi, A. and Srivastava, R. 2012. Impact of climate change on agriculture and food security. *ICRIER Policy Series*, No.16.
- Thakur, S. and Chand, K. 2013. Food Security in India. *Third Concept* 27 (322): 27-32.
