ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

NATURAL DISASTERS AND THEIR REDUCED FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT

Shelke Pradip Abasahe , Research Student (JRF), Government college of Education (IASE) Aurangabad , Maharashtra

ABSTRACT

Natural disasters play a major role in agricultural development and the economic cost associated with all natural disasters has increased 14-fold since the 1950s. Drought is a many faceted natural disaster that leads to serious socioeconomic impacts particularly affecting agricultural production and water supplies. There are two distinct phases in which the application of the knowledge of weather and climate can reduce the impact of drought on the communities. The first is the long term planning in which strategies can be devised, and precautions taken to reduce impact. The second phase is the action taken during the onset of the event to reduce adverse effect. Efforts were made to stabilize dryland agriculture by evolving contingent crop production strategies in rainfed areas of India. Drought management policies included agricultural planning and practices with consideration of overall water requirement within the individual agroclimatic zones.Natural disasters are classified into hydro-meteorological and geophysical disasters. Definitions of various types of hydrometeorological disasters such as floods, droughts, cyclones, forest fires, and heat waves were presented. Evidence available from different parts of the world showed that there is a rising trend in the occurrence of natural disasters from 1950 to 2005. Impacts of natural disasters on agriculture, rangeland, and forestry were described. Environmental degradation is one of the major factors contributing to the vulnerability of agriculture, forestry, and rangelands to natural disasters because it directly magnifies the risk of natural disasters. Traditional definitions of sustainable development focussed on balancing agricultural productivity and environmental concerns. Today, however, it is important that the idea of sustainable development be extended beyond the notion of minimizing environmental impact; it should address issues such as managing vulnerability and enhancing the capacity to adapt and respond to natural disasters. In this sense, the sustainable agricultural development matrix should include a component of disaster risk management and reduction. There is an urgent need to mitigate the effects of hydrometeorological disasters through the improved use of climate and weather information and forecasts, early warning systems, and appropriate methods of land management and natural resources.

INTRODUCTION

Disasters do not affect all people and sectors in the same way, or to the same extent, and these differences have important policy implications. For example, as this study illustrates, specific types of hazards cause more agricultural losses than others, the agriculture subsectors are affected differently by disasters, and the nature of disaster impact on the sector differs by region and country. It is therefore necessary to understand the breadth and scope of disaster impact on agriculture and livelihoods, such as the extent to which disasters increase the level of food insecurity or arrest sector economic growth. Agriculture is a complex system, within which changes are driven by the joint effects of economic, environmental, political, and social forces (Olmstead, 1970; Bryant and Johnston,1992). It is very well known that agriculture is inherently sensitive to climate conditions and is among the sectors most vulnerable to weather and climate risks. Environmental degradation and the destruction

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

of natural barriers is one of the major factors contributing to the vulnerability of agriculture, forestry, and rangelands.

In order to ensure sustainable agricultural production and assure the livelihood of millions of people, especially in the developing countries, a better understanding of the natural disasters that impact agriculture, forestry, and rangelands is essential. Awareness of the need to give greater attention to disaster mitigation, preparedness, and management has been growing among decision makers. Pre-disaster preparedness now forms an integral part of national development planning in many countries.

Agriculture and Natural Disasters

Every year natural disasters, such as hurricanes, floods, fires, earthquakes, and tornadoes, challenge agricultural production. Because agriculture relies on the weather, climate, and water availability to thrive, it is easily impacted by natural events and disasters. Agricultural impacts from natural events and disasters most commonly include: **contamination of water bodies, loss of harvest or livestock, increased susceptibility to disease, and destruction of irrigation systems and other agricultural infrastructure**. These impacts can have long lasting effects on agricultural production including crops, forest growth, and arable lands, which require time to mature. Learning how to prepare for and recover from natural events and disasters will decrease their long-term effects on agriculture and the environment. Even though natural events and disasters can be devastating to agricultural production, it does not excuse noncompliance with state and federal environmental laws. The link below provides resources and assistance in planning and preparing for and responding and recovering from natural disasters. In addressing the impacts of natural disasters, the agricultural sector has not received the attention that it deserves from the policy makers since most of the economic impacts in this sector are attributable to relatively "small" events. Often it is the large headline-catching disasters that receive the attention of the public and policy makers. In the words of Swiss Re (2002), "unspectacular climatic anomalies, which the general public perceives as 'unusual,' rather than 'catastrophic' weather conditions, can cause losses on a scale normally associated with natural catastrophes." The cost of coping with such climatic anomalies is rising because of a combination of changes in the nature of natural disasters and the increasing vulnerability of society to these disasters (IPCC, 2001). Costs not absorbed by national governments, foreign aid, or insurance fall on the poor farmers.

The poorest in the rural areas occupy the most marginal lands and this forces people to rely on precarious and highly vulnerable livelihoods in areas prone to natural disasters such as droughts, floods, etc. The ability to adapt to extreme weather events is lowest in the poorest segments of society and in countries where resources, information, and skills are limited; technology is often unavailable; institutions are unstable or weak; and empowerment and access to resources is inequitable Sustainable agricultural systems should provide for the needs of current, as well as future generations, while conserving natural resources (Natural Research Council, 1991). The enhancement of the environmental quality and careful use of the resource base on which agriculture depends is viewed as a requisite to sustained agricultural productivity. Today, however, it is important that the idea of sustainable development be extended beyond the notion of minimizing environmental impact; it should

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

address issues such as managing vulnerability and enhancing the capacity to adapt and respond to natural disasters. In this sense, the sustainable agricultural development matrix should include a component of disaster risk management and reduction.

Natural Disasters – Definitions and Types

In simple terms, a natural event such as a flood, earthquake, or hurricane that causes great damage or loss of life."the number of people suffering food crises as a result of natural disasters has tripled in the last thirty years describe disasters as the interface between an extreme physical environment and a vulnerable human population. Such definitions emphasize the fact that the socio-economic and political factors are of paramount importance in understanding why populations are vulnerable to the environment and experience disasters. According to International Federation of Red Cross and Red Crescent Societies (2003), natural disasters include hydro-meteorological disasters and geophysical disasters. The hydro-meteorological disasters include landslides/avalanches; droughts/famines; extreme temperatures and heat waves; floods; hurricanes; forest/scrub fires; windstorms; and others (insect infestation and waves/surges). The geophysical disasters include earthquakes and volcanic eruptions. In this paper, only the hydro-meteorological disasters impacting agriculture, rangeland, and forestry are dealt with. Sivakumar (2005) provided a description of the definitions of each of these disasters which is given below.

A landslide is a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flow. Although gravity acting on an overly steepened slope is the primary reason for a landslide, there are other contributing factors. An avalanche is caused when a build up of snow is released down a slope, and is one of the major dangers faced in the mountains in winter. An avalanche is a type of gravity current. Drought is the consequence of a natural reduction in the amount of precipitation over an extended period of time, usually a season or more in length, often associated with other climatic factors (such as high temperatures, high winds, and low relative humidity) that can aggravate the severity of the event. Drought is not a purely physical phenomenon, but instead is an inter-play between natural water availability and human demands for the water supply. The precise definition of drought is made complex due to political considerations, but there are generally three types of conditions that are referred to as drought.

- **Meteorological drought is brought about when there is a prolonged period with below average precipitation.**
- **Agricultural drought is brought about when there is insufficient moisture for average crop or range production. This condition can arise, even in times of average precipitation, due to soil conditions or agricultural techniques.**
- **Hydrologic drought is brought about when the water reserves available in sources such as aquifers, lakes, and reservoirs falls below the statistical average. This condition can arise, even in times of average (or above average) precipitation, when increased usage of water diminishes the reserves.**

A heat wave is a prolonged period of excessively hot weather, which may be accompanied by excessive humidity. The term is relative to the usual weather in the area, so temperatures that people from a hotter climate find normal can be a heat wave if they are

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

outside the normal pattern for a cooler area. The term is applied both to "ordinary" weather variations and to extraordinary spells of heat, which may only occur once a century. Flood is defined as the condition that occurs when water overflows the natural or artificial confines of a stream of other body of water, or accumulates by drainage over low-lying areas. A flood is a temporary inundation of normally dry land with water, suspended matter and/or rubble caused by overflowing of rivers, precipitation, storm surge, tsunami, waves, mudflow, lahar, failure of water retaining structures, groundwater seepage, and water backup in sewer systems. Forest fire (or bushfire in Australasia) is an uncontrolled fire occurring in vegetation more than 6 feet (1.8 meter [m]) in height. These fires often reach the proportions of a major conflagration and are sometimes begun by combustion and heat from surface and ground fires. Tropical cyclones, hurricanes, and typhoons are regional names for what is essentially the same phenomenon. Depressions in the tropics which develop into storms are called tropical cyclones in the southwest Indian Ocean, the Bay of Bengal, the Arabian Sea, parts of the south Pacific. A tsunami (Japanese for big wave in port), which is often incorrectly called a tidal wave, is a series of massive waves that occur after an earthquake, a seaquake, volcanic activity, slumps or meteorite impacts in or near the sea. Since the constant energy of the tsunami is defined by height and speed, its height increases once its speed is reduced where the wave approaches land.

The waves travel at high speed, more or less unnoticed where crossing deep water, but rising to a height of 30 m and more when approaching land. Tsunamis can cause severe destruction on coasts and islands.

Impacts of Natural Disasters in Agriculture, Grassland, and Forestry

Impacts from natural disasters on agriculture, **Grassland**, and forestry can be positive or negative. While the impacts are predominantly negative and do affect human society significantly, there are some positive impacts or benefits that can occur (Joy, 1991).

As Das (2003) explained, the impact of natural disasters on agriculture, rangeland, and forestry can be direct or indirect in their effect. Direct impacts arise from physical damage on crops, animals, and trees caused by the extreme hydro-meteorological event. The impacts may be considered in terms of short-term, temporary damage at a particular crop stage to complete crop loss. Within hours of their occurrence, natural disasters produce direct damage to agriculture in terms of total or partial destruction of farm buildings, installations, machinery, equipment, means of transport, storage as well as damage to crop land, irrigation works, dams, and destruction of crops ready for harvesting.

Disasters also cause indirect damage which refers to loss of potential production due to disturbed flow of goods and services, lost production capacities, and increased costs of production. Such indirect impacts appear progressively as a result of low incomes, decreases in production, environmental degradation, and other factors related to the disaster

Many famines in pre-20th century Africa, Asia, and Europe were triggered by natural disasters, including drought, extreme cold, pests, and diseases that devastated crops and livestock (Devereux, 2000). Loss of perennial crops such as banana trees or forests has long-term consequences on the ability to generate income. In the case of agricultural income generating assets, the loss might be temporary or permanent (Charveriat, 2000). Floods make land unsuitable for agricultural production until waters recede, while hurricanes might wash

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

out arable land or permanently increase its salinity through storm surges and flash floods. Indirect impacts include the evacuation of people in the event of cyclone landfall, disruption to households, stress induced sickness, and apprehension.

The economic consequences also concern the activities related to international trade, which have become indispensable because of national debt. Export agriculture, tourism, crafts, and industrial activities are assumed to bring in foreign currency that is indispensable for the equilibrium of the balance of payments. Agricultural export products hold an even more significant place. Free zones can be affected by cyclones and floods with greater probability as they are situated in the coastal plains and on the principal deltas. In Bangladesh, the Chittagong free zone was very seriously affected by the
1991 cyclone.

Reduced the Impacts of Natural Disasters

Natural disasters as an integral component of poverty reduction and sustainable development.Disasters threaten livelihoods as well as international and national efforts to advance development and eradicate poverty. Even if it is not possible to prevent natural disasters, much can be done to build capacities to reduce the vulnerabilities that too often lead to a crisis situation.Communities that are most exposed to risk from climate extremes and natural disasters and potentially at risk from climate change, are those with limited access to technological resources and with limited development of infrastructure. Countries, especially the geographically smaller ones, cannot be expected to cope alone because each one needs to have information on the full extent and magnitude of natural disasters. Socio-economic losses cannot be entirely eliminated, but timely and appropriate mitigation measures can certainly reduce the impacts.

The Plan of Implementation of the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002 highlighted the need to mitigate the effects of droughts and floods through such measures as improved use of climate and weather information and forecasts, early warning systems, land and natural resource management, agricultural practices, and ecosystem conservation in order to reverse the current trends and minimize degradation of land and water resources. WSSD noted the need to promote the access and transfer of technology related to early warning systems and to mitigation programmes to developing countries affected by naturaldisasters.

Improved use of Climate and Weather Information and Forecasts

The interaction between weather and agricultural production is so complex (Hoogenboom, 2000) that it is not just a case of developing a simple solution and expecting farmers to implement it. Each year or season will bring a different set of circumstances and hence the farmers have to make their decisions based on each situation. Hence a participatory approach involving the representatives of the National Meteorological and Hydrological Services (NMHSs), the agricultural extension agencies, and the farmers is necessary. One basic requirement is the awareness of the influence of weather and climate parameters on sustainable agricultural production. In many cases, this awareness is acutely present and many farmers often look for intelligent, low-risk solutions. This should stimulate an interest among the farmers to evaluate the forecast products produced by the NMHSs. In the past 2 decades, significant advances have been made in the science and applications of seasonal

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

climate forecasting. The principal scientific basis of seasonal forecasting is founded on the premise that lower-boundary forcing, which evolves on a slower timescale than that of weather systems, can give rise to significant predictability of atmospheric developments. These boundary conditions include sea surface temperature (SST), sea-ice cover and temperature, landsurface temperature and albedo, soil moisture, and snow cover, although they are not all believed to be generally of equal importance. Climate variations, also called anomalies, are differences in the state of the climate system from normal conditions (averaged over many years, usually a 30- year period) for that time of the year. The strongest evidence for long-term predictability comes largely from the influence of persistent SST anomalies on the atmospheric circulation which, in turn, induces seasonal climate anomalies. The key weather variables for crop prediction are rainfall, temperature, and solar radiation, with humidity and wind speed playing also a role. As Doblas-Reyes, et al., (2006) explained, seasonal climate forecasts are able to provide insight into the future climate evolution on timescales of seasons and longer because slowly-evolving variability in the oceans significantly influences variations in weather statistics. The climate forecast community is now capable of providing an end-to-end multi-scale (in space and time) integrated prediction system that provides skilful, useful predictions of variables with socio-economic interest. Seasonal forecasts can be produced using mathematical models of the climate system.

Operational empirical-statistical methods, based on statistical links between current observations and weather conditions in the future, include analysis of general circulation patterns; analogue methods; timeseries, correlation, discriminant, and canonical correlation analyses; multiple linear regression; optimal climate normals; and analysis of climatic anomalies associated with El Nin o-Southern Oscillation (ENSO) events.

Early Warning Systems

A fundamental condition for disaster preparedness is the availability of risk assessments and well functioning early warning systems that deliver accurate and useful information in a timely and dependable manner to decision makers and the population at risk. While natural hazards may not be avoided, the integration of risk assessment and early warnings with prevention and mitigation measures can stop many hazards from becoming disasters. This means that action can be taken to considerably reduce the resulting loss of life and socio-economic damages. Without doubt, a fundamental pre-condition for disaster preparedness is a well-functioning early warning system, capable of delivering accurate information to the population at risk, dependably, and in a timely manner.

There is a growing global awareness of the importance of early warning systems. During the Second World Conference on Disaster Reduction (Hyogo, Kobe, Japan, January 2005), 168 countries adopted the Hyogo Framework for Action 2005-2015 (HFA) and identified five high priority areas, of which the second stressed the need for "identifying, assessing, and monitoring disaster risks and enhancing early warnings," as a critical component of disaster risk reduction. From 1980 to 2005, over 7,000 natural disasters worldwide have taken the lives of nearly two million people and produced economic losses of over one trillion U.S. dollars. However, as the number of disasters and their economic impacts increased during the period, the number of fatalities was diminishing. For example, for disasters related to weather-, water-, and climaterelated hazards, there has been nearly a 4-

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

fold increase in the number of disasters and a 5-fold increase in the economic losses, but nearly a 3-fold decrease in loss of lives. This noteworthy achievement is due to several factors, one of which is the development of specific end-to-end early warning systems (Jarraud, 2006). Over the recent years, new technologies have brought about an accelerated increase in our knowledge of the climate system. Satellites for monitoring aspects of the oceans and sparsely populated parts of the globe; ocean buoys, and expendable bathythermographs for monitoring the physical and chemical properties of the oceans; hundreds of specially equipped commercial aircraft; and manned and automatic weather stations on land, are all expanding the volume of data and contributing to knowledge base.

In relation to any kind of hazard, such as flash floods, disaster mitigation can only be successful provided that there is enough lead-time for appropriate measures to be taken, in order to save lives and to reduce the impacts. The use of numerical weather prediction (NWP) products is a way to provide an increase in the lead-times to a greater degree than could be achieved by the use of radars alone. Today, state-of-the art technologies include improved terrestrial and spacebased observation systems, as well as increasingly accurate models and the necessary telecommunication means to relay observations, in near real-time, to the forecasting and warning centers. This is especially true in the area of medium-range weather forecasting, which with the development of ensemble prediction systems (EPS), permit evaluation of the uncertainty in the forecast. Such systems need to be adapted to local circumstances and to be fully utilized, in order to extend the lead-time, especially in the developing countries. With the aim to improve flood forecasting, WMO has launched its Flood Forecasting Initiative with the objective of further improving the capacity to deliver timely and more accurate flood forecasting products and services. This is occurring through effective cooperation of the National Meteorological Services (NMSs) and National Hydrological Services (NHSs) as well as capacity building activities in collaboration with the disaster managers. Major advances in technology, notable progress in scientific understanding, and the accuracy and timeliness of weather and flood warnings have significantly improved over the last few decades. Today the accuracy of forecasts of large-scale weather patterns for 7 days in advance is the same as those for 2 days in advance only 25 years ago (Obasi, 1998). Now forecasts up to 10 days are showing remarkable accuracy, and there is now capability to provide some skillful information on expected weather patterns several seasons in advance. For example, early information on El Niño episodes is now allowing advanced national planning, with considerable advantage in many sectors of the economy, such as in water resources management, tourism, fisheries, and agricultural production (Obasi, 1996). In the case of the 1997-98 El Niño event, advances in El Niño related science and in monitoring the sea-surface temperatures in the Pacific Ocean, enabled scientists in the NMHSs to predict its formation longer in advance than all the previous events. With recent developments in communication technology, including use of the Internet, information on the El Niño is disseminated in a rapid and timely manner throughout the world. These have enabled many governments to take appropriate measures, stimulated international cooperation, and integrated efforts to address the associated impacts.

Effective early warning systems coupled with community education for protective action have reduced the potential human loss from these events. Floods as a disaster also lend

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

themselves well for preparedness measures both structural and legislative (land use laws, zoning plans, and urbanization). Preparedness of life-saving techniques and evacuation plans should be promoted actively in these high risk zones.

More Efficient Management of Land and Water Resources

When prolonged natural disasters such as droughts occur, the high temperatures and low precipitation in the dry lands lead to poor organic matter production and rapid oxidation. Low organic matter leads to poor soil aggregation and low aggregate stability leads to a high potential for wind and water erosion. For example, wind and water erosion is extensive in many parts of India . Excluding the current deserts, which occupy about 46 percent of the landmass, about 25 percent of the land is prone to water erosion and about 22 percent to wind erosion. On the contrary, during periods of heavy rainfall, eg., during cyclones, rainfall can erode soil by the force of raindrops, surface and subsurface runoff, and river flooding. The velocity of rain hitting the soil surface produces a large amount of kinetic energy which can dislodge soil particles. Erosion at this micro-scale can also be caused by easily dissoluble soil material made water soluble by weak acids in the rainwater. The breaking apart and splashing of soil particles due to raindrops is only the first stage of the process, being followed by the washing away of soil particles and further erosion caused by flowing water. The greater the intensity of rainfall and subsequent surface runoff, the larger the soil particles carried away.

New farm technologies and those that have been established for many generations – indigenous technologies – offer many opportunities to mitigate the impact of natural disasters. Because of the projected climate change, the optimization of farm technologies becomes even more important for the productivity of various agricultural production systems at different input levels (Sivakumar, et al., 2005). Farmers cannot only change crops and cultivars but also modify crop management, for example, by changing the sowing date according to the expected seasonal weather. The seasonal precipitation pattern (onset of rain, duration of rainy season, and distribution during crop-growing period) is one of the most important pieces of information for farmers in semi-arid regions using rain-fed cropping, especially for low-input systems in developing countries, which enables them to adapt their sowing dates and crop selection (Stigter, et al., 2005; Ingram, et al., 2002; Mati, 2000). Matthews, et al., (1997) reported that for rice production in Asia the modification of sowing dates at high latitudes, where higher temperatures allowed a longer potential crop-growing season, permitted a transition from single cropping to double cropping in some locations, which could had a significant effect on regional production. Two shorter ripening varieties might be a better strategy than a longer maturing variety because the grain formation and ripening periods are pushed to less favorable conditions later in the season.

The ever-increasing water demand in contrast to the slow increase in water supply is leading to unsustainable water use and competition for water resources in agriculture. This trend has serious implications for sustainable agricultural development, especially in the developing countries. Proper management of water resources by application of appropriate farm technologies plays and will play a major role in both developed and developing countries in regions with limited resources for agricultural production. For example, irrigated agriculture in the Mediterranean area was introduced in ancient times and has been improved over time with experience. However, irrigation techniques have been maintained in the same way for centuries in most Mediterranean countries. Inefficient flooding irrigation systems, for example, can be still found in many areas of Spain and Egypt (El Gindy, et al., 2001; Neira, et al., 2005). Modern sprinkler and drip-irrigation systems have been introduced at great expense in some Mediterranean European regions such as Spain (MAPA, 2005). These new techniques significantly reduce water use. Improved management of watersheds through establishment of water spreading, harvesting, and storage facilities as well as the use of supplementary irrigation techniques are needed to improve and develop rain-fed agriculture. Techniques such as "deficit irrigation" should be considered as an option in the next decades, or irrigated agriculture will become unaffordable (Fereres, 2005). At the same time, it is also essential to curtail losses of conveyance and on-farm use of irrigation water through appropriate measures. Guidelines need to be developed for the rational use and proper management of the vast but mostly non-renewable groundwater resources that are available in varied water qualities in huge aquifers.

Conclusion

According decisions and thus help secure more appropriate levels and forms of disaster prevention, mitigation, and preparedness. Historical studies would also help inform the development of appropriate methodologies for the assessment of future disasters. Despite a long history of disasters affecting agriculture, rangelands, and forestry, comprehensive documentation of these disasters at the national, regional, and international levels has been weak; and it is important to develop mechanisms for more efficient assessment and documentation of natural disaster impacts in agriculture. A comprehensive assessment of impacts of natural disasters on agriculture requires a multi-sectoral and integral approach involving key organizations. Priority should be given to supporting research with practical applications since research is needed to understand the physical and biological factors that contribute to disasters. Since the major impact of natural disasters is on poor farmers with limited means in developing countries, community-wide awareness and education programs on natural disasters should be a priority. Programs for improving prediction methods and dissemination of warnings should be expanded and intensified. Efforts are also needed to determine the impact of disasters on natural resources.

References

1. Aghajanian A (1978). Fertility and Family Economy in the Iranian Rural Communities. J. Compar. Fam. Stud.,
2. Ajami I (1976). Different Fertility in Peasant Communities: A Study of Six Iranian Villages. Populat. Stud.,
3. Bryant, C.R. and T.R.R. Johnston. 1992. Agriculture in the City's Countryside, London Pinter Press.
4. Charveriat, C. 2000. Natural disasters in Latin America and the Caribbean: an overview of risk.
5. Doblas-Reyes F.J., R. Hagedorn and T.N. Palmer. 2006. Developments in Dynamical Seasonal Forecasting Relevant to Agriculture. *Climate Research*
6. Fereres, E. 2005. Deficit (supplemental) irrigation. In Proceedings of InterDrought-II Congress, Roma.

ISSN
(Print) 2320 – 6446, (Online) 2320 – 8341

7. Funaro, C. 1982. Natural disasters and the development process: a discussion of issues. Washington, D.C.: United States Agency for International Development.
8. Guha-Sapir, Debarati, D. Hargitt, and P. Hoyois. 2004. Thirty years of natural disasters 1974- 2003: The numbers. Louvain: UCL Presses Universitaires de Louvain.
9. Hansen J.W. and M. Indeje. 2004. Linking dynamic seasonal climate forecasts with crop
10. Shankar, K. (2008). Wind, water, and Wi-Fi: New trends in community informatics and disaster management. The Information Society, 24(2), 116-120. Retrieved from www.emeraldinsight.com/10.1108/01435120210697216 simulation for maize yield prediction in semi-arid Kenya. *Agric For Meteorol.*
11. Hoogenboom, G. 2000. The state-of-the-art in crop modeling. *In:* (M.V.K. Sivakumar, ed.). Climate Prediction and Agriculture. Proceedings of the START/WMO
12. International Workshop held in Geneva, Switzerland, 27-29 September 1999. Washington, D.C., USA: International START Secretariat.
13. Höppe, P. 2007. Scientific and Economic Rationale for Weather Risk Insurance for Agriculture.
14. *In*: (M.V.K. Sivakumar and R.P. Motha, eds.) Managing Weather and Climate Risks in Agriculture. Berlin: Springer.
15. NRC (National Research Council). 1991. Toward Sustainability. A plan for collaborative research on agriculture and natural resource management. Board on Science and Technology forInternational Development. Washington, D.C.: National Academy Press. Rajiv Gandhi Institute for Contemporary Studies. New Delhi, India.
16. Salinger, M.J., Sivakumar, M.V.K., Motha, R. 2005. Reducing vulnerability of agriculture and forestry to climate variability and change: Workshop summary and recommendations. *Climatic Change*.
17. mauLo, ra.SaM. AaiNa]maazo, iva.tu. ³1998´. *SaOxaiNak saMSaaoQanaacaI maUlat<vao*. AaOrMgaabaad : ivaVa p`kaSana.
18. maaoro, jyaaotIrama, ibacauklao, BaagyaEaI. ³naaovhoMbar¹2009´. *pyaa-varNa iSaxaNa AaiNa Aap<aI vyavasqaapna*. naaiSak : [nasaa[-T piblakoSana.
19. Saalaoya [ya<aa navavaIcao pazyapustk. maharaYT/ rajya pazyapustk inaima-tI va AByaasaËma saMSaaoQana maMDL, puNao *: [ya<aa navavaI. ivaYaya ¹ Aqa-Saas~* ¹ p`qamaavaR<aI ¹ 2006

saMkot sqaLo

1. www.google.com
2. www.shodhganga.in
3. www.climateprediction.net
4. www.climatehotmap.org