Household Vulnerability Analysis of Climate Change Impact to Food Insecurity

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Review of Related Literature

Food security

The UN's Food and Agriculture Organization (FAO 2008), defines food security as a situation "when most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat" (Anbumozhi& Portugal, 2011, p.5). The FAO identifies four main dimensions of food security: physical availability of food, economic and physical access to food, food utilization and stability of the other three dimensions over time.

Echoed by Anbumozhi & Portugal (2011), they argue that in looking at food systems these four dimensions of food security identified by FAO should be taken into consideration. Food availability refers to the global and regional food supply. Food accessibility on the other hand refers to the ability of individuals to purchase food in sufficient quantities and quality. Food stability refers to the maintenance of the continuity of food supply of seasonal production. And food utilization refers to the food consumption patterns, malnutrition, pest contaminations, diseases and people's capacity to obtain necessary nutrients from the food they consume.

According to the FAO, "for food security objectives to be realized, all four dimensions must be fulfilled simultaneously" (FAO, 2008).

Building on the FAO definition of food security, Pinstrup-Andersen (2009) suggests that "a household is considered food secure if it has the ability to acquire the food needed by its members to be food secure". He makes a distinction between transitory and permanent food insecurity, where the former describes "periodic food insecurity as for example seasonal food insecurity, while the latter describes a long-term lack of access to sufficient food". He adopts the USDA measure of household food security which "is based on household self-declarations, differentiates between low and very low food security…on the household-level resource constraints"(i.e. does the household have the resources to acquire the food needed?).

Ziervogel, et.al. (2006) looked at food security in terms of availability, access, utilization, and livelihoods. They argue that a livelihoods understanding in defining food security is useful because "itemphasizes the importance of looking at an individual's capacity for managing risks, aswell as the external threats to livelihood security, such as drought" (p.8).

According to Anbumozhi & Portugal, "Food security can be evaluated under two different perspectives: from a micro and a macro level. The micro-level food security refers to household and individual levels and evaluates the nutritional well-being of individuals, whereas the macro-level food security focus at a national policy level and assesses regular supplies of food in national, regional, and local markets." (p.5).

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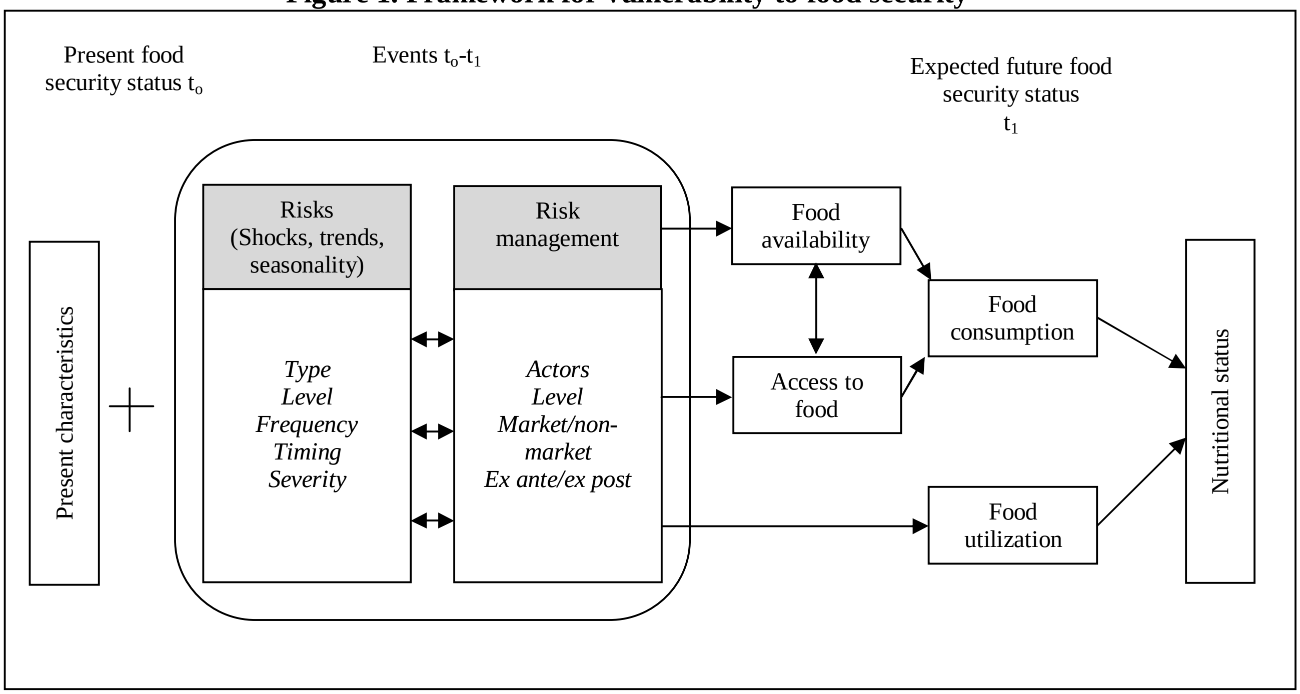
According to the FAO, vulnerability in terms of food security refers to the "group of factors that places people in a situation where they are at risk of food insecurity, including factors that undermine people's capacity to deal with the situation" (FAO, 2000).

Lovendal& Knowles (2006) linked food security and vulnerability in their research. They provide a definition of vulnerability in terms of food security. They define vulnerability "relative to the negative outcome of food security and define as vulnerability refers to people's propensity to fall, or stay, below the food security threshold within a certain time frame". They offered a framework for understanding food security by including risks and the ability at different levels to manage these to reduce the probability of people being food insecure in the future. The suggested framework looks at present characteristics of food security status, risks such as shocks, trends and seasonality, and risk management to predict future food security status which is measured by food availability, access to food, food consumption, food utilization and nutritional status.

Figure 1. Framework for vulnerability to food security



Source:Lovendal& Knowles (2006)

On the macro-level, according to the ADB report on Food Security and Climate Change in the Pacific (2008), the factor influencing food security include food importation, global food and fuel prices, disasters and emergencies, and factors such as traditional and subsistence agriculture, land and water resources, increased urbanization and globalization, technological constraints to agricultural production and private investment on agricultural production.

Echoing the importance of looking at food importation, Gingrich, et.al. (2001) showed in their study that foreign exchange availability greatly affects food security in food-importing countries such as Indonesia and the Philippines. They argue that a combination of foreign exchange supplies, cereal prices and domestic cereal production determine the relative cost of food security imports. One implication, according to them, is that both countries should further diversify their export sectors to help stabilize export revenues.

On the other hand, Hoddinott&Yohannes (2002) suggest an alternative measure of food security. Using data from India, the Philippines, Mozambique, Mexico, Bangladesh, Egypt, Mali, Malawi, Ghana, and Kenya, they suggested using dietary diversity as an alternative measure because of four reasons, “1.) a more varied diet is a valid outcome in its own right; 2.) a more varied diet, either directly or indirectly through improved acquisition of micronutrients, is associated with a number of improved outcomes in areas such as birthweight, child anthropometric status, improved hemoglobin concentrations, reduced incidence of hypertension, reduced risk of mortality from cardiovascular disease and cancer; 3.) such questions can be asked at the household or individual level, making it possible to examine food security and the household and intrahousehold levels and 4.) obtaining these data is relatively straightforward”.

They define dietary diversity as the number of unique foods – foods were divided into categories: basic staples, luxury staples, vitamin-A rich, other roots and tubers, other fruits, other vegetables, a beverages, spices and others. This was included with four other indicators of food security (per capita expenditures, caloric availability, caloric availability from staples, and caloric availability from nonstaples). They concluded that the use of dietary diversity as an alternative measure is feasible and has uses.

Gittelson, et.al., (1998) note that “food security has long been used as an important macro-level indicator of agricultural stability and progress for both agricultural and economic researchers,” however, little work has been done to operationalize the concept at the household level” (p.210). They argue that household food security as a concept should integrate “environmental, economic, and cultural factors” (p.210).

Sanchez (2000) suggests an integrated natural resource management approach that aims to address issues of food security while addressing poverty reduction while satisfying societal objectives for environment protection. The approach includes “identifying and quantifying the extent of food insecurity, rural poverty and resource degradation problems to be addressed in a given region, enhancing the direct utilitarian functions of natural resources, which consist of food, raw materials and income in the case of agriculture, enhancing the ecosystem functions of natural resources, such as carbon, nutrient and water cycling, erosion control and biodiversity, assessment of trade-offs between the options that enhance the food and income functions of systems and those options that enhance the ecosystem functions” and dissemination.

Webb, et.al., (2006) expands the discussion on how to measure food security by suggesting a more qualitative approach. They suggest that measures for food insecurity should “1.) shift from using measures of food availability and utilization to measuring “inadequate access” (key to access is purchasing power and varies in relation to market integration, price policies and temporal market conditions) ; 2.) shift from a focus on objective to subjective measures; and 3.) emphasize fundamental measurement as opposed to reliance on distal, proxy measures”.

Building on the FAO definition of food security Napoli (2010) notes that “an integral part of the multi-dimensional nature of food security is the nutritional dimension” (p.19) and that as mentioned earlier food security consists of four essential parts: food availability, food access, food utilization and stability.

On the other hand, the United States National Food Security Measure employs a more micro-level approach by looking at the dietary intake, nutritional status and physical well-being of individuals. The measure also assesses the “cognitive and affective components of uncertainty, unacceptability or unsustainability” (Wolfe &Frongillo, 2001, p.6) such as insecurity over future intake. Growth status is also used as an indicator, as well as precursors to food security such as income, total expenditure, and coping strategies. Wolfe &Frongillo (2001), in this regard, suggests that the experience of food insecurity itself is an important measure.

Anriquez, et.al. (2012) offers a "guideline to construct household specific dietary energy requirements, in a way which is consistent both with the different needs of populations according to their physical constitute on, age and gender; and consistent with the way FAO calculates energy requirements". They suggest that to be able to determine which household or individual is food insecure and to be able quantify food energy gap, "actual household (individual) calorie intake should be compared with a relevant energy requirement threshold" which quantifies the necessary (minimum) or the recommended (average) energy requirement, tobalance the energy expenditures needed to maintain body size and composition, and a level of necessary (minimum) or desirable (average) physical activity that is consistentwith good health in the long run(Anriquez, et.al., 2012).

Sarris &Karfakis (2010) in their study, developed a measure of rural household vulnerability whichestimates idiosyncratic shocks. The methodology "integrates amajor source of covariate shocks, withestablished techniques for estimating idiosyncratic shocks to estimate vulnerability ofrural households in two regions of Tanzania". The findings suggest that the "major covariate risk relates to weather induced production variations as well as price variations that give rise toagricultural income variations" which make households vulnerable and forces them to adopt strategies such as "income and crop diversification" and "consumption smoothing strategies".

Capaldo, et.al. (2010) proposed a vulnerability model to food security that sees vulnerability " result of a recursive process: current socio - economic characteristics and exposure to risks determine households' future characteristics and their risk - management capacity. This framework builds on the framework put forward by Lovendal& Knowles (2006) (see Figure 1 above).

The FIVIMS is broadly defined to "include any information system – or network of systems – that monitors the situation of people who are poor or vulnerable to transitory and/or chronic food insecurity". According to Weissman, et.al., (2002), the FIVIMS "are networks of systems that assemble, analyse and disseminate information about the problem of food insecurity and vulnerability" which aims to raise awareness about food security issues, improve the quality of food security-related data and analysis, promote donor collaboration on food security information systems at country level, encourage better action programmes on poverty and hunger, and to improve access to information through networking and sharing" (p.278). According to Fresco &Baudoin (2002), "at the international level, FIVIMS implements diverse activities in support of national information systems, to enable them to become part of an international information exchange network" and "at the country level, FIVIMS works with a network of information systems that gather and analyse relevant national and sub-national data that measure food insecurity and vulnerability.

Building on the FIVIMS, Devereux, et.al. (2004) proposes a FIVIMS Integrated Livelihoods Security Information System' (FILSIS) which supports a "two-track approach to fighting both food insecure ty (i.e. dealing with shocks) and underlying household income poverty (i.e. strengthening livelihoods)." was Focuses on livelihoods rather than poverty. Devereux, et.al.(2004) suggests that a livelihood approach to food security "might provide a practical toolkit for linking the analysis of food insecurity with a multi-dimensional and people-centred analysis of poverty – looking beyond income and consumption levels to include an assessment of people's strategies, assets and capabilities"

Food security and climate change

According to Anbumozhi& Portugal (2011), there are four ways by which climate change would have effect on crop production and food security:

1. Changes in temperatures and precipitation
2. Carbon dioxide effects
3. Water availability
4. Agricultural loses

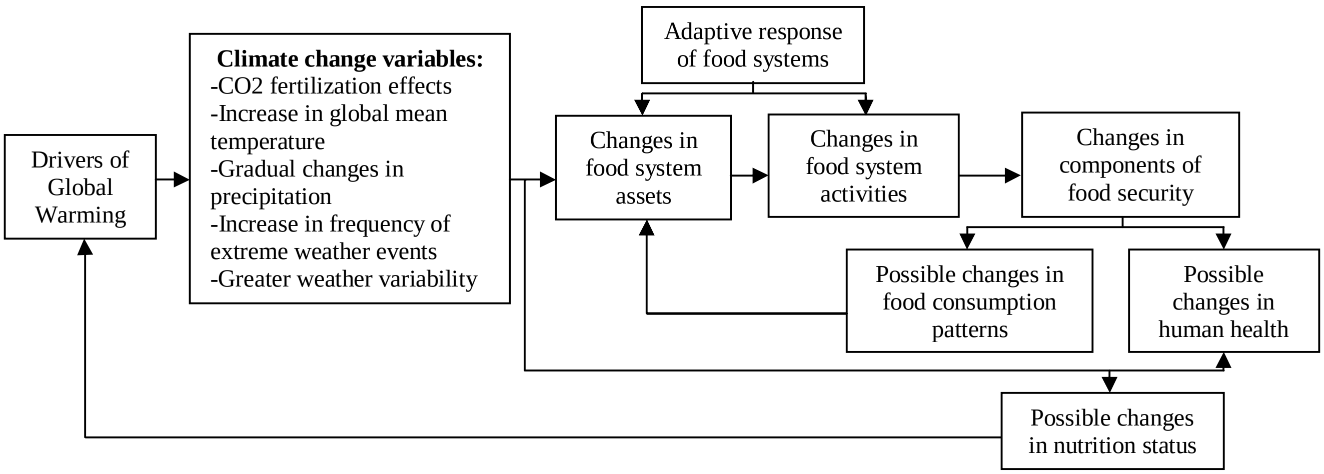
Table 2. Potential impacts of climate change on food systems

Climate Change Impacts	Direct consequences for food systems
Increased frequency and severity of extreme weather events	• Decreases in crop yields • Loss of livestock • Damage to fisheries and forests • Either an excess or shortage of water • Disruption of food supply-chains • Increased costs for marketing and distributing food
Rising temperatures	• Increased evapotranspiration, resulting in reduced soil moisture (land degradation and desertification) • Greater destruction of crops by pests • Greater threats to livestock health • Reduced quantity and reliability of agricultural yields • Greater need for cooling/refrigeration to maintain food quality and safety • Greater threat of wildfires
Shifting agricultural seasons and rainfall patterns	• Reduced quantity and quality of agricultural yields and forest products • Either an excess or shortage of water • Greater needs for irrigation
Sea level rise	• Damage to coastal fisheries • Direct loss of cultivable due to inundation an salinization of soil • Salinization of water sources

Source: Anbumozhi& Portugal, 2011

The figure below shows a conceptual framework from FAO "describing the dynamics of potential climate change impact and positive and negative feedback loops in the food security components." (Anbumozhi& Portugal, 20011, p.6).

Figure 2. Climate change variables and impacts on food security



Source:Anbumozhi& Portugal, 2011

Lobell, et.al., looked at crop specifically to assess the impacts of climate change on food security. According to Lobell, et.al. (2008), "crops which have relative strong dependence of historical production on rainfall were considered cases with uncertainties" suggesting that it is not sure whether or not climate change would have effect on these crops)."To ascertain which crops would most likely be affected by climate change, they expressed the need for more precise projection of rainfall. Finally, they suggested putting investment (prioritize) on crops that will be least affected by climate change, not a simple changing of planting dates or shifting to other crops.

In an earlier work, Rosenzweig& Parry (1994) looked at the potential effects on agricultural production (and hence food security) of climate change. Using a world food trade model to simulate the economic consequences of potential changes in crop yields to estimate changes in world food prices and in the number of people at risk of hunger. One finding is that there seems to be a big disparity between developed and developing countries in terms o agricultural vulnerability. General Circulation Model (GCMs) were tested in terms of CO2 levels, yield changes estimates, and farm-level adapatations. Adaptation included were changes in planting date, variety, crops, and applications of irrigation and fertilizer. In the world food trade model, it is predicted that in the climate change scenario, without direct CO2 effects, world cereal production would be reduced by 11 to 20 percent. Upon inclusion of CO2 effects, yield decreases between 1 to 8 percent. Price increases are estimated to be between ~24-145 percent and the number of hungry people would increase by ~1 percent for every 2-2.5 percent increase in prices. People at risk of hunger increase by 10 percent to almost 60 percent. Upon inclusion of farm adaptation in the world food trade model, world production levels are restored.

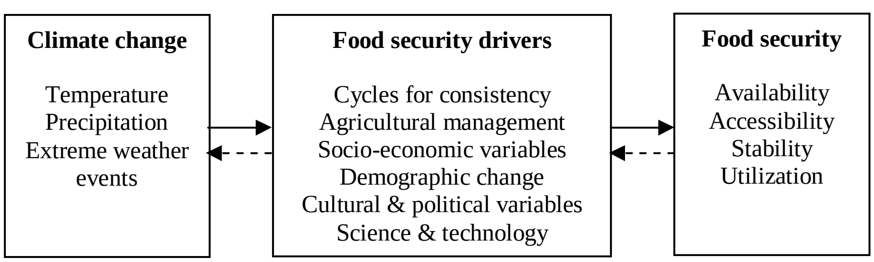
Scenarios near the high end of the IPCC range of doubled CO2 warming exerted slight to moderate negative on cereal production. The only scenario that yielded positive cereal production was one involving a major and costly changes in agricultural systems (i.e., installation of irrigation). In sum, climate change is found to increase disparities in cereal production between developed and developing countries.

Building on Rosenzweig& Parry (1994), Parry, et.al (2004) suggests that changes in regional crop yields under each scenario are the result of the interactions among temperature and precipitation effects, direct physiological effects of CO2, and effectiveness and availability of adaptations.

Arnell, et.al. (2004) on the other hand suggests that "the future impacts of climate change will depend to a large extent on the future economic, demographic, social and political characteristics of the world". The paper downscaled the IPCC's Special Report on Emissions Scenarios (SRES) world-region population and economic data scenarios to the national and sub-national scales for a global climate impact assessment of future food scarcity, water stress, exposure to malaria, coastal flood risk and wetland loss and terrestrial ecosystems. They suggested that urban and rural growth rates be considered. Two limitations of the SRES scenarios were identified: first, "there are considerable difficulties involved in moving from the scale at which the SRES scenarios were produced (11–13 world regions) to the much finer spatial resolution required by impacts models. A number of rather major assumptions had to be made, most specifically that all parts of a region would change at the same rate: this was applied to population, GDP and land cover" and; second, "whilst the SRES land cover trends are consistent with the narrative storylines, they are inconsistent with recent trends. Under none of the storylines is there a sustained continued deforestation, for example, and crop areas decrease under all of them".

Ziervogel&Eriksen (2010) offers a framework for assessing the impacts of climate change on food security. They discussed linkages between climate change (temperature, precipitation, and extreme weather events), food security (availability, accessibility, stability and utilization) and its drivers (cycles for consistency, agricultural management, socio-economic variables, demographic change, cultural and political variables and science and technology).

Figure 3. Linkages between climate change and food security



Lifted from Ziervogel&Eriksen, 2010

According to them, the key issues that should be addressed to respond to food insecurity and managing transitions or innovation in cropping system include: chronic poverty, functioning markets, farmer attitudes toward managing risks, and reforming or improving the institutions responsible for managing food and agricultural systems.

In the Philippines, the Department of Agriculture expects the following impacts of different climatic events as shown in the table below:

Table 3. Expected impacts of global climate change in the Philippine agricultural sector

No	Climatic Events	Impact	Source/Assumptions
1	Rainfall	Decrease by 20 percent, but increase in intensity. Increase risk of soil erosion and occurrence of landslides.	• IPCC 2007 • Godilano, E.C. 2005 • FAO (2006)
2	Rainy Days	Decrease rainy days but intensity will be higher than normal, growing periods may shorten by approximately 30 days	• Rosenzweig and Parry, 1994 • IPCC 2007
3	Cyclone	Increase intensity and occurrence and may trigger landslides and flooding of coastal areas.	• IPCC 2007
4	Maximum temperature	Increase by three percent, more frequent and persistent El Niño episodes, and increased evaporation. Crop duration shortened between one and four weeks. Drought will be longer and more intense, heat waves occurrence.	• IPCC 2007 • NOAA, 2007
5	Flooding	Increase flooding depth, frequency, intensity, and severe landslides. Submergence of coastal communities and costalerosion	• IPCC 2007, Brackenridge, G.R. and Anderson, E. (2004) • Dartmouth Flood Observatory USA (2009)
6	Ground Water Potential (GWP)	Decrease water availability, poor quality, and salt intrusion	• IPCC 2007 • Godilano, E.C. 2005
8	Cloudiness	Increase in total cloud cover, decrease photosynthesis. Clouds regulate the amount of sunlight received by the surface and so influence evaporation from the surface, which in turn influences cloud formation	• NOAA, 2007 • NASA Water Vapor Project (NVAP) 1992

Source: Department of Agriculture Policy and Implementation Program on Climate Change

Impacts on crops

As to how the production of crops would be affected most by climate change, results vary. Most however argue that climate change would affect different crops differently.Lobell& Field (2007) note that for crops that rely too much on water such as rice and soybean, precipitation would be key in explaining the effect of climate change but for other crops, temperature should be considered.

In the Philippines, agricultural production, according to Buan, et.al., (1996) is "traditionally concentrated on a few main crops [with] rice and corn [as] the major food crops" (p.42) and corn acts as a major substitute for rice especially for Central Luzon and "is the main ingredient for livestock feeds, food products, and is important in industrial uses." (p.42). On the other hand, "coconut and sugarcane are the major commercial crops that constitute important export commodities" (p.42). Buan,et.al.,(1996) notes that both rice and corn crops are "highly vulnerable to climate variability". Climate-related occurrences have historically affected rice and corn production losses between 1968 and 1990 according to Buan, et.al., (1996). The study showed that for all scenarios results showed consistent decrease in corn yield, while for rice, results were rather more varied.

In a study on the relationship between yields for soybean and corn and climate trends, Kucharik&Serbin (2008) noted that temperature and precipitation both affected corn yields while for soybean yields, precipitation "had a slightly larger impact on theoverall multiple regression results" (p.7).

Alexandrov, et.al., (2002) also note the varied impacts of climate change on different crops. Showed that "the increase in simulated soybean seed yield for the next century was caused primarily by the positive impact of warming and especially by the beneficial direct CO2 effect" (p.379). On the other hand, decrease in the winter wheat yield "was caused primarily by a shortened growing season owing to projected warming and some increases in precipitation during the crop-growing season" (p.379). However, increasing the level of CO2 in the scenarios showed an increase in the yield of winter wheat. Comparing the two, if the CO2 levels increases, soybean yield will show a decline and winter wheat yield will increase.

The simulations conducted by Conde, et.al., (1997) showed that "under incremental temperature and precipitation scenarios resulted in favourable (rain-fed maize) yield changes" (p.19). What their study suggested that aside form precipitation and increase in CO2, important factors should also be considered such as soil and historical yield data.

Table 3. Summary of effects of climate change on crops

Crops	Scenario		Effect	Sensitivity to	Source
	Precipitation	Temperature			
Winter wheat	Increase	Increase	Decrease yield		Alexandrov, et.al., 2002
Soybean	Increase	Increase	Increase yield	Precipitation	
Wheat, maize barley		Increase	Decrease		Lobell& Field, 2007
Corn		Increase	Decrease yield		Buan, et.al., 1996
Corn/Maize		Increase	Increase yield	One possible	Conde,

				explanation for the increase was the climate of the region, which was usually affected by frost	et.al., 1997
	Increase		Decrease yield		
Rice			Different for each rice variant	Maturity period of rice varieties maybe needed to consider	Buan, et.al., 1996
			Variance in yield	There maybe other climate influences not accounted for	Lobell& Field, 2007
	Increase (minimum temperature in July-August)	Increase/Decrease in July –August	Increase in yield	But in general an increase in temperature by as small as 0.3C is associated with a decline in yield, though there may be increase in yield if temperature increase by 1.5C and 3.0C, demand for irrigation water would be induced (evapo-transpiration	Mahmood, et.al., 2012
	Increase (maximum temperature in July-August)		Decrease in yield		
	Decrease (minimum temperature in September-October)		Increase in yield		
	Decrease (maximum temperature in September-October)		Decrease in yield		
	Decrease (min & max temperatures in September-October)	Increase	Decrease in yield		

Adaptation to climate change

A survey of the literature showed that oft-cited short-term adaptation strategies include "changes in planting dates and cultivars; changes in external input such as irrigation; techniques in order to conserve soil water" (Alexandrov, et.al., 2002, p.383). For example, for Austria, Alexandrov, et.al., (2002) suggested that spring crops be sown earlier “in order to reduce yield loss or to further increase the projected gain resulting from an increase in temperature” (p.384).

Conde, et.al (1997) assessed the potential increase in production costs as a result of the implementation of adaptive measures to reduce climate change impacts. They suggested fertilization as a measure for adapting to climate change in Mexico. However they noted the importance of subsidies from governments to be able to continue both maize production and fund the use of fertilizers. However they also noted that “under a non-subsidy policy, the application of this adaptive measure would become unfeasible due to the high production costs involved, since profits would be reduced and losses could even occur” (p.21).

Burke &Lobell (2010) on the other hand differentiating between ex-ante and ex-post measure. While ex-ante measures refers to the action taken in “anticipation of a given climate realization” which often center around diversification of crops among others; ex-post measures are responses “undertaken after the event is realized” which include “drawing downcash reserves or stores of grain, borrowing from formal or informal credit markets orfamily, selling assets such as livestock, or migrating elsewhere in search for work innon-affected regions” (p.135). However, Burke &Lobell (2010) argued that not all strategies for adaptation are available to farmers. They noted that “existence of social safety nets and functioning financialmarkets ensure that farmers are either insured against losses, can borrow aroundthem, or can receive help from the government to maintain livelihoods during badtimes” (p.135).

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