
The assessment of the socio-economic impacts of climate change at household level and policy implications

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INTRODUCTION

The effects of gradual climate changes and extreme weather events in the recent past have undermined progress in the alleviation of poverty and food insecurity, while also having a negative effect on overall development efforts. Economic sectors that largely depend on weather conditions – either directly or indirectly – most notably agriculture and fisheries are increasingly subject to the impacts of climate change (IPCC, 2012). Moreover, the depletion of natural resources, as a result of increased environmental and demographic pressures, tends to aggravate the severity of climate change impacts. All in all, there are increasing concerns about the rising threats to current income and consumption patterns of households and individuals that earn their livelihoods from these sectors (Foresight, 2011; IPCC, 2012).

Evidence from global models indicates that farming populations residing in tropical (low latitude) regions are expected to experience deterioration in their agricultural yields and incomes. As a consequence, the incidence, depth and persistence of poverty and food insecurity will increase. Estimations for these regions suggest that yield losses for maize, wheat and rice range between 5 and 20 percent, should local temperatures increase by 3 °C; yield levels may halve if temperatures increase by as much as 5 °C. Expected economic losses range between a little as 0.5 and as much as 23.5 percent of a country's gross domestic product (GDP). In temperate (higher latitude) regions, yields may actually increase or decrease slightly, translating into changes in GDP that range between small losses and gains of up to 13 percent (IPCC, 2007; Tol, 2009). Nelson *et al.* (2010) estimate climate change will increase the number of malnourished children from 8.5 to 10.3 percent over the baseline scenario.

Nonetheless, critical methodological and evidence gaps exist with regard to the downscaled assessment of the impacts at the household level (FAO, 2008a). These constraints limit our understanding of the channels through which climate-related changes and extreme events affect vulnerable households. This lack of understanding further reduces our ability to design and implement effective policy measures aimed at either assisting at-risk households to prevent or mitigate negative impacts of future shocks

or implement other risk management strategies, such as adapting their livelihoods, or responding appropriately to the burden of future shocks.

In particular, the way to approximate the different patterns with which changes in climate and weather conditions impact the livelihoods of the households working in agriculture and fisheries or other affected groups, is frequently circumstantial. Any relevant framework that intends to downscale and assess the impact of climate changes and weather shocks at household level needs to properly recognize and correctly define the nature of usually interdependent changes and extreme events that hit different types of livelihoods. For instance, gradual changes in temperatures or precipitation have to be considered along with changes in the timing and length of rainfall seasons or the incidence of extreme weather shocks. The resolution of such identification issues is a critical step in order to fully understand the impact of extreme events and gradual changes in climate.

Critical knowledge gaps exist as well on how welfare losses (or potential benefits) from gradual or extreme climate events are distributed among households. Poor farmers, pastoralists or fisherfolk are usually considered as most threatened by the effects of climate changes and weather shocks on the basis of possible disruptions in the production process. Urban poor consumers are also threatened if food prices increase¹ in order to reflect both the impact of climate changes or if the true cost of food is adjusted to reflect environmental concerns.

However, behind higher vulnerability to poverty or food insecurity resulting from adverse climate events, there is a range of factors that reveal the weaknesses of households to cope *ex post* or manage *ex ante* the events. These factors reflect households' lower adaptive capacity and higher susceptibility to the impacts of the events and refer to low levels of human and physical capital, insufficient access to assets and services (public or private), weak institutional structures, inexistent or inefficient social protection programmes and greater exposure to uncertainty in the physical and economic environment (Skoufias *et al.*, 2011).

The objective of the present paper is to assist in describing a framework that could be employed to assess the socio-economic impacts of weather shocks and climate changes on agricultural households and particularly farmers in developing countries. In the following sections the paper discusses: (i) a framework for the assessment of impacts resulting from climate changes and weather shocks in food security at household level; (ii) the use of two methodological tools that are able to assess the vulnerability to food insecurity as well as the resilience of farming households to the incidence of climate change and extreme events; (iii) preliminary evidence on the welfare losses measured by increases in poverty, food insecurity breakthroughs or health-related impacts as are discussed in this relatively nascent literature, and; (iv) an outline of key policy messages for successful adaptation options at household level and particularly for farmers. A final section summarizes the paper.

¹ Price increases, however, signify a positive shock for agricultural producers and fisherfolk.

CLIMATE CHANGE – WEATHER SHOCKS AND LIVELIHOODS IN AGRICULTURE (THE SOCIO-ECONOMIC PERSPECTIVE)

Projections indicate that changes in weather elements will not necessarily manifest themselves through slow changes, nor will they be uniform across different regions and agro-ecological zones. While it is expected that the frequency, duration and intensity of hot spells will increase (number of hot days, maximum and mean temperatures) in all parts of the world, the same is not expected to happen for rainfall precipitation.

Farming, pastoralist, fisheries and forestry sectors and the livelihoods therein are directly sensitive to climate variability and changes. Food security implications are expected to emerge in general as follows:

- Food production and supply at global and local levels:
 - benefits in temperate regions may offset losses in tropical areas (but global availability of food does not necessarily imply satisfaction of each of the food security pillars locally);
 - disruption in trade and distribution channels resulting from extreme weather events.
- The livelihoods of groups involved directly or indirectly with agricultural and fisheries production and trade are also threatened:
 - producer groups that are unable to adapt to climate change or cope with weather shocks;
 - upward price adjustments may benefit net producers of food that are integrated into markets but net consumers in urban or rural areas that are not somehow involved in agriculture and fisheries will be hurt.

The climate change elements considered in the Climate Change and Food Security (CCFS) framework affect biophysical factors (for instance, plant development) and agricultural management practices, as well as different capital items (infrastructure, productive assets, human capital including health) that directly or indirectly are employed in food systems (FAO, 2008a). A comprehensive assessment of the impacts on food security should monitor, as closely as data permit, climate change and weather elements such as:

- mean, maximum and minimum temperatures (related with that is the number of growing degree days of crops);
- gradual changes in precipitation:
 - frequency, duration and intensity of dry spells and droughts;
 - changes in the timing, duration, intensity and geographic location of rain and snowfall;
- the incidence, frequency and intensity of storms, floods, droughts or other extreme events;
- the seasonal variability of weather elements and changes in start/end of growing seasons;
- the CO₂ fertilization effect of increased greenhouse gas concentrations in the atmosphere.

So far, the frequency and intensity of extreme events, along with irregularities in seasonal weather patterns, influence food production, food distribution, food emergencies,

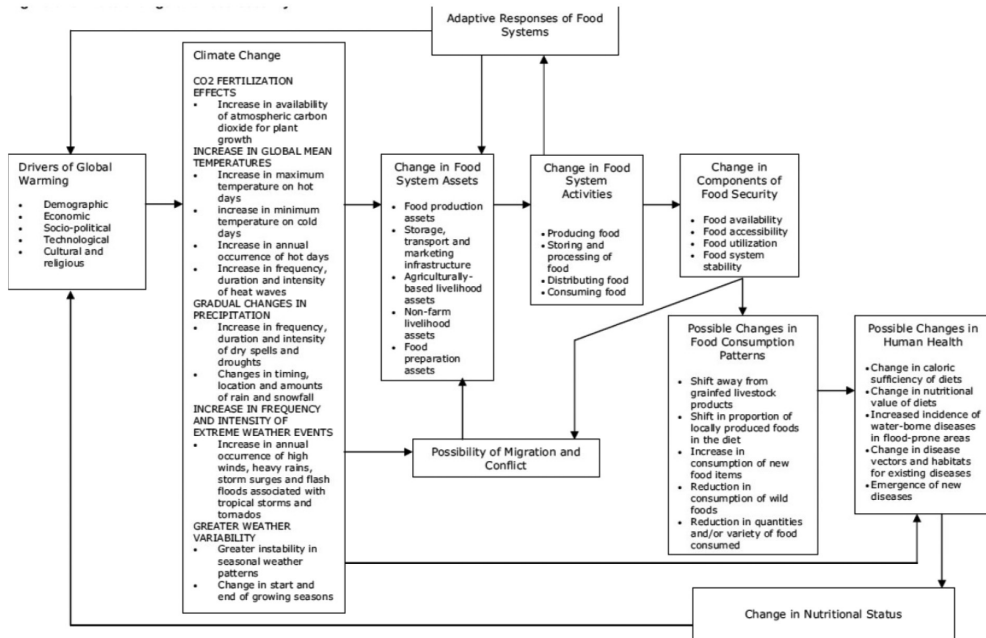


Figure 1. Climate change and food security

Source: FAO (2008a).

infrastructure, assets and human capital in rural and urban areas. In addition, the slow onset of climate changes will be evident in the properties of land for farming and pasture, forestry, fisheries, biodiversity and ecosystems.

Changes in climate are expected not only to change the average levels of key weather elements but also to increase their variability along with the frequency of weather shocks. The complex and diverse character by which climate changes manifest themselves requires multilevel approaches in studying their socio-economic impacts as well as the impacts on food security (Figure 1).

From the socio-economic point of view, a schematic approach to changes in the aforementioned weather elements is offered by Skoufias and Vinha (2012) and Figure 2. First, changes in the environment affect consumption of rural livelihoods through their impacts on agricultural production and income, since farm yields are directly affected by weather elements. *Ex ante* risk management and *ex post* shock-coping abilities of the household, respectively, may or may not be able to insulate or smooth consumption from income/yield effects. Given the income risk or shock, some reallocation of resources within the household is also likely to take place.

Second, health-related effects may also be expected, indirectly if food or other (e.g. health-related commodities) resources are downsized, or directly if changes in weather elements affect the prevalence of diseases or the level of the risk associated with the exposure to non-trivial weather changes.

The indirect (through income and resource availability and reallocation) or direct interplay between environment, on the one hand, and health and consumption, on the

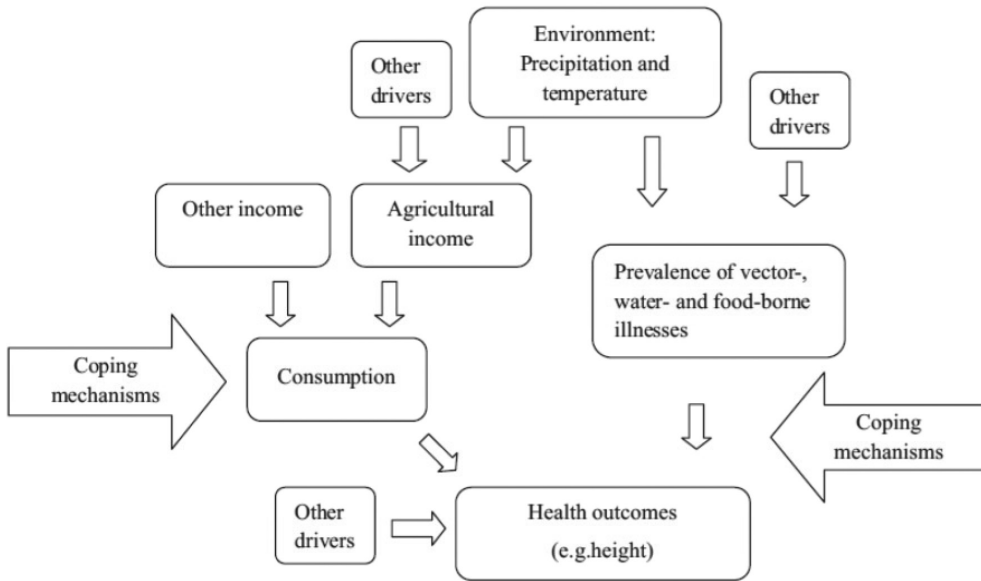


Figure 2. The channels of impact of climatic variability on different dimensions of household welfare
 Source: Skoufias and Vinha (2012).

other, eventually determines the final welfare impact of climate changes locally in any time perspective. The evidence indicating that an environmental shock may have a positive indirect but a negative direct impact on health is noteworthy. For instance, Galindo (2009) shows that, in Mexico, the same increases in temperature or precipitation may benefit or damage crop yields depending on the region, the category of crops and the season in which they occur. While these changes increase yields in temperate climates, negative health effects have also been observed as breeding conditions for illnesses improved in tropical regions. Thus malnutrition and other health-related effects may appear, especially if an individual is already poorly nourished when the weather event occurs in the tropical regions of the country.

Nevertheless, increases in temperature and rainfall are shown to affect crop yields positively as long as those increases do not go out of the range that hinders the development of the plants. Other socio-economic characteristics such as age, the level of human capital and gender also influence the relative impacts of climate changes. For instance, it has been shown that a positive rainfall shock in India increases the survival probabilities of girls relative to the boys.

In developing countries, different groups are vulnerable to different types of climate events and the impacts those have impact on incomes and consumption (McMahon, Lipper and Karfakis, 2011). Accounting for loss of access to natural resources, production shortfalls, decreases in incomes and food price impacts, a rough grouping of affected types of households in developing countries includes (Figure 3):

- **Self-sufficient households without access to markets.** Subsistence farmers, herders, fishers and forest-dependent households that produce food for their own consump-

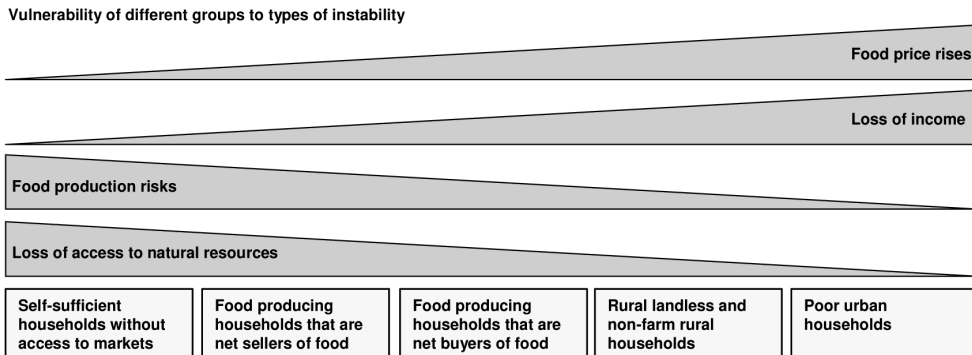


Figure 3. Vulnerable population groups in view of multilevel risks

Source: McMahon, Lipper and Karfakis (2011).

tion are subject to risks such as the loss of access to natural resources and to production shortfalls associated with climate variability effects. However, they represent a small number of people (in rural Malawi, 5 percent of all households do not buy or sell anything to the markets; in Nepal, this proportion increases to 8 percent; Karfakis *et al.*, 2011b).

- **Food producing households that are net sellers of food.** Within rural economies there are households that produce and sell more food than they purchase. They are a significant group in developing countries (mainly in rural areas); an analysis of 12 low-income countries shows that, on average, 31 percent of rural households were net sellers of food (FAO, 2008b). These households are vulnerable to loss of access to natural resources, and to the variable productivity of their resources, but they may benefit from food price increases.
- **Food-producing households that are net buyers of food.** Most farming households in developing countries are both buyers and sellers of food. They are vulnerable both to production risks and to higher food prices. The interaction between these risks depends on the relative movement in prices of different agricultural commodities and on the extent to which these households rely on off-farm income.
- **Rural landless, non-farm rural and poor urban households.** Their food security depends on relative changes in incomes and in (local or global) food prices. As non-producers, they are not directly affected by production risks, although their employment prospects and incomes may be affected by the poor performance of the agriculture sector.

Across these groups, a gender dimension is also evident. Women and female-headed households are at risk, in both urban and rural areas. Either as food consumers or as food producers, female-headed households tend to have reduced access to assets (e.g. land and other physical or human capital), savings and credit (FAO, 2008b). As a result, women farmers typically achieve lower yields than men, which makes them more vulnerable to production and income shocks (FAO, 2011).

METHODOLOGICAL TOOLS FOR (FARM) HOUSEHOLD VULNERABILITY AND RESILIENCE ANALYSIS

The concrete impact of the gradual onset or the sudden incidence of climate changes and shocks on different aspects of household food security or poverty is a field of study that presents relatively scarce evidence even nowadays. This is initially the outcome of knowledge gaps on the side of assessing how any shock affects the multidimensional and dynamic concept of food security and all of its pillars. On the other hand, however, knowledge gaps exist on the side of correctly identifying the type of the weather shock along with the channels through which climate changes are transmitted to household welfare of different household groups, as was described earlier.

Empirical evidence strongly indicates that food security is characterized by high volatility so much that stability in food security constitutes another of its pillars. As such, households and their members find it extremely difficult to obtain steady, adequate access to sufficient available food and to consume it (i.e. utilize) in the most efficient (and equitable between members) way. Thus, the World Food Summit defined food security as universal and permanent access to sufficient, safe and nutritious food (FAO, 1996).

Evidently, food security policies should try to accommodate both the assessment of households' current state of welfare and their expected access, availability and use of food. Therefore, minimizing the impacts of future food insecurity asks for policy-makers and households themselves to manage and adapt to the uncertainty and expected risks.

Vulnerability to food insecurity analysis resulting from climate change

Vulnerability analysis is able to cope with some of these issues given its ability to provide a relatively more dynamic overview of household welfare. With the use of a household survey as minimum data requirements, an estimate of the probability for a household being food insecure in the near future can be computed. Vulnerability as a probability to become food insecure considers a measure of food security (usually, calorie intake or value of food consumed per capita or per equivalent adult units), as a function of:

- Household characteristics and specifically:
 - demographic features;
 - assets (physical, social, human capital or other);
 - income sources characteristics;
 - geography and others.
- Exposure to climate-change risks.
- Capacity to cope with weather shocks or other climate events.

The methodology works in two interdependent steps, employing multivariate analysis in both of them:

1. the direct impact of climate changes on agricultural productivity and farm income, is initially explored; and;
2. through this impact, the effect on food consumption and food security is assessed.

This tool eventually is able to provide an estimate of the distribution of expected food consumption and, along with the use of a predetermined food security threshold, the probability for each household to become food insecure. This probability, alongside

the current food insecurity status of the household, enables the profile of food insecure households to be built more accurately, setting the pace for better-designed and targeted policies.

Through its forward-looking lens, vulnerability analysis allows important distinctions to be made between the food poor and/or vulnerable and the food non-poor and/or more resilient groups of the population. In this way, food-insecure but not-vulnerable households, being able to improve their situation without major external assistance (e.g. transitory food-insecure), are distinguished from those that are unlikely to improve their situation single-handedly (i.e. chronically food-insecure and vulnerable). As such, vulnerability analysis is able to strengthen the design of interventions, enhancing food security.

Vulnerability analysis also allows the explicit identification of climate change as a major risk and other factors that threaten food security of farmers. Hence, this analysis can assist in the design of safety nets – interventions that will help reduce these risks and/or improve risk management capacities. Vulnerability analysis is able to accommodate the multiple dimensions of food insecurity,² in terms of the asset base, flows of incomes, farming productivity, access to resources and services at the household or communal levels. Thus, the profiling of vulnerable groups is built on a more solid basis, improving the reliability of the safety net policies in terms of design and implementation.

In terms of policy, the relative effectiveness of different policy tools can also be evaluated through analysis that can simulate how quantifiable policy options on their own, or in conjunction with each other, can be used to reduce vulnerability to food insecurity of households affected by climate change or other risks. An exercise in Nicaragua indicates how policies that are associated with developmental outcomes (i.e. education), or improved agricultural practices (i.e. wider input use), reduce expected vulnerability to food insecurity, which is projected to increase significantly by 2030 as temperatures follow a steadily upward trend.

A literature review describing in some length how vulnerability analysis emerged as an analytical tool, assessing the food security status of households dynamically while explicitly accommodating risks and shocks, including concrete aspects of climate change, can be found in Karfakis *et al.* (2011a). The paper applies the methodology in the study of the impact of climate change on Nicaraguan farmers (the results of this exercise are discussed later in this paper). The review starts from Sen's work (Sen, 1983), who initiated economic research on poverty and welfare, acknowledging the importance of uncertainty and its implications for household welfare. It describes how the concept, initially introduced to natural sciences and finance, was adapted to poverty analysis by Ravallion (1988), Chaudhuri (2001), Chaudhuri, Jalan and Suryahadi (2002) and Christiaensen and Boisvert (2000) and references therein. In poverty analysis, vulnerability computes the probability that a welfare indicator (usually total consumption per capita) will fall below a predetermined threshold in the near future.

² For instance, this analysis may provide some evidence of households locked in a poverty or food security trap. Exposure to risks and lack of capacity to handle the impact of shocks may enforce the choice of income-earning strategies with lower variance but also low mean earnings. Appropriate policy interventions employing social safety nets may be necessary in this case to reduce exposure to risk and uplift the household from the poverty trap.

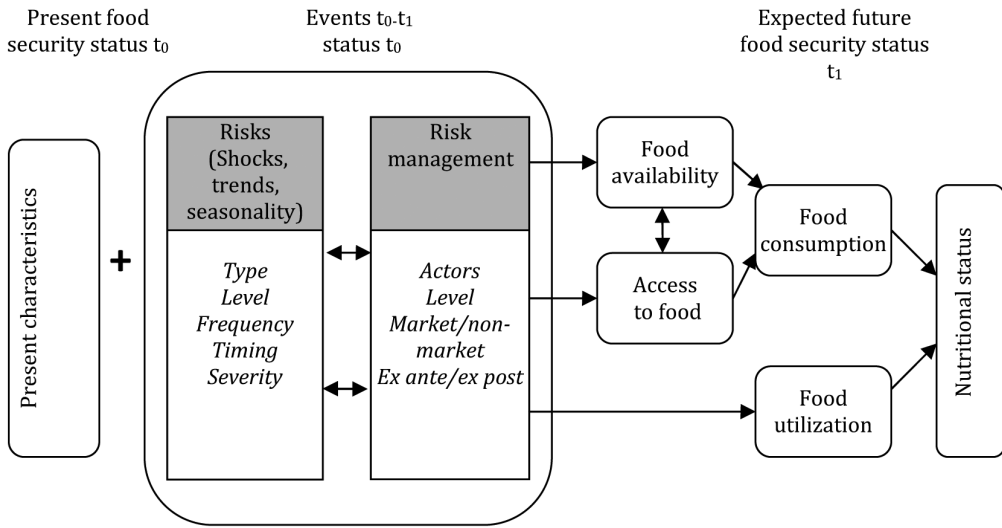


Figure 4. A framework for analysing vulnerability to future food insecurity

Source: Løvendal and Knowles (2005).

The conceptual framework for vulnerability to food insecurity resulting from changes in climate is based on the proposal of Løvendal and Knowles (2005). This framework (along with vulnerability to poverty analysis) is based on the Social Risk Management approach (Holzmann and Jørgensen, 2000). The framework sees vulnerability as the likelihood of being food insecure in the future and is a function of present characteristics, exposure to risks emerging from changes in climate and the characteristics of these risks, as well as the capacity of the households to manage or cope with them. In the context of climate change, the risks and their characteristics have to do with weather changes and climate shocks as described in the previous section. The framework is summarized in Figure 4.

Resilience analysis as a tool to assess the impacts of climate change

FAO has also been testing resilience analysis (Alinovi *et al.*, 2009) to assess how households adjust their livelihoods after perturbations. Resilience is usually defined as the ability of groups or communities to cope with external stresses and disturbances resulting from social, political and environmental changes (Adger, 2000). In a food security context, however, resilience is defined as the ability of a household to keep at a certain level of well-being (i.e. be food secure) by withstanding shocks and stresses. This depends on available livelihood options and on how well households are able to handle risks. This definition implicitly considers both *ex ante* actions that reduce the risk of households becoming food insecure and *ex post* tools that help households cope after a crisis occurs.

The resilience tool provides a framework for understanding the most effective combination of short- and long-term strategies for moving families out of traps of poverty and undernutrition. The resilience framework tries to address the root causes of household vulnerability instead of trying to predict how well households will cope with future crises or disasters. The factors that make households resilient to food security shocks can

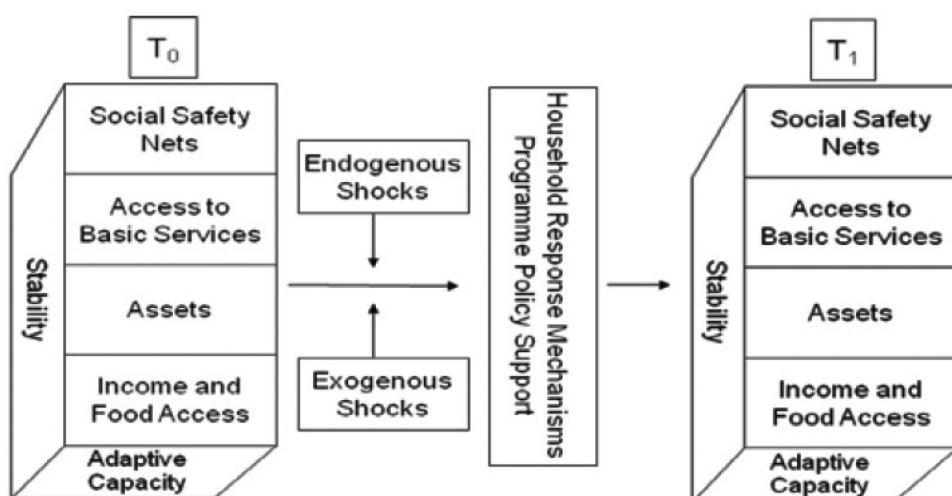


Figure 5. A framework for analysing household resilience to food insecurity

Source: FAO (2010).

be integrated into four basic pillars (Figure 5) that determine the stability and adaptive capacity of each one of them and include:

- income and access to food;
- assets such as land and livestock;
- social safety nets such as food assistance and social security;
- access to basic services such as water, health care and electricity.

Non-parametric analytical methods are employed to combine these factors into an index that gives a quantitative resilience score for each household. Further analysis indicates which pillar(s) of resilience need(s) to be strengthened to further build household resilience. The insight into why and how people become food insecure suggests ways of preventing this from happening. In a study for Nicaragua, Ciani (2011) showed how the resilience score of different household groups changed (declined) after the incidence of hurricane Mitch. If interventions are designed in ways that increase resilience by enhancing people's ability to manage risk, including climate-related events and shocks over time, then the need for humanitarian interventions when hazards occur will diminish.

In general terms, resilience and vulnerability analyses should not be seen as alternatives, but as complements. Vulnerability analysis tends to measure the susceptibility of people to damage when exposed to particular hazards or shocks. It often focuses on one specific target variable, usually represented by the household consumption expenditure (for food or total consumption). Both analytical tools use data available from national household budget surveys such as the Living Standard Measurement Surveys (LSMS) or Household Income and Expenditure Surveys (HIES).

By pinpointing the specific factors that make households resilient, the framework gives decision-makers clear indications of where to intervene. For example, resilience analysis in Palestine shows that there is a big difference in how households headed by women and those headed by men cope with shocks. Women have fewer assets and less access to

different sources of income than men. Thus, households headed by women rely heavily on public services and social safety nets. A policy that further cuts safety nets and public services would thus have a severely negative impact on these women and their families.

PRELIMINARY EVIDENCE FROM HOUSEHOLD LEVEL ANALYSIS OF CLIMATE CHANGE IMPACTS

Global or economy-wide models have been most frequently used to assess the impacts of climate change on the economy.³ For example, Nordhaus (2010) and Olivieri, Rabassa and Skoufias (2010) estimate that projected aggregate impacts on poverty under the baseline scenario, under business as usual or an emission abatement path are marginal (even though GDP is projected to decline 1.5 percent by 2055). Such marginal effects are justified since mitigation policies (such as abatement policies) affect in principle the welfare of higher income regions and countries.

At subnational level, two major types of methods are employed to study the impacts of climate change.⁴ The first strand of work tries to estimate how land rents (e.g. farmland revenues net of purchased input costs) would change in view of climate variability as well as other characteristics (economic conditions, soil quality, etc.). This type of analysis (usually called “the Ricardian approach”) is based on the economic rationality that, when farmers maximize profits, land rents should reflect the net revenue value of farmland; in that case, changes in weather should be reflected in revenue changes as well. This approach in the context of climate change has been suggested by Mendelsohn, Nordhaus and Shaw (1994), and has been applied to India (Jacoby, Rabassa and Skoufias, 2011), Ethiopia (Deressa and Hassan, 2009), 11 African countries (Kurukulasuriya *et al.*, 2006) and possibly elsewhere.

A second strand of empirical research selects a welfare measure and explores the impact of climate changes on household welfare directly. This welfare measure may be a measure of household consumption or income, poverty or a health-related indicator. In the present review most attention is given to the second type of empirical evidence.

Heterogeneity in the adverse effects is the major message emerging from the type of models that try to assess the impact at sectoral level within a country through time or through household level analysis.⁵ Either because of location, as a result of differentiated access to assets or the diverse structure of income sources (diversification) and expenditures, the welfare impact is different across household groups. For instance, it is estimated that agricultural output per hectare in Brazil may decline on average 18 percent by 2040, but impacts are positive in certain communities (up to +18 percent) and negative in others (up to -40 percent) (Assunção and Chein, 2009). Jacoby, Rabassa and Skoufias (2011) also show that heterogeneity is the major message with regard to the impact of climate changes on consumption in India. While average productivity may fall by about 13 percent in 2040,

³ At cross-country level, a wide range of research has been carried out on the impacts of climate change. The work by Lobell, Schlenker and Costa-Roberts (2011) on the negative impact of temperature increases on the yields of the major food crops (especially maize and wheat) since 1980 is noted here. Also Schlenker and Lobell (2010), using growing degree days to capture the impact of temperature increases, show that average yield losses in sub-Saharan Africa are expected to range around -22 percent for maize, -17 percent for sorghum and millet and -18 percent for groundnuts.

⁴ Vulnerability analysis to some degree integrates both types of empirical approaches.

⁵ Skoufias, Rabassa and Olivieri (2011) provide a thorough review of the evidence at cross-country and subnational levels.

rural and landless households are expected to see relatively small reductions in their per capita consumption (about 5 to 6 percent) as a result of increases in incomes and wage earnings from farm activities that will become more profitable after agricultural prices increase. These estimates, however, still suggest that poverty rates may increase (1 to 6 percent) and that climate changes hurt mainly the poor. In general, returns to land and wage labour are expected to decline and, especially for land, large-holders will be mostly hurt. Nevertheless, associated increases in the prices of crops will reduce, neutralize or even generate positive welfare effects for some households.

The results in India vary by household characteristics (e.g. land size) while some adaptation options (changes in production methods, in crop mix or other) are also accounted. In particular, market-based (or autonomous) adaptation strategies reduce welfare losses from -11 to -6 percent. Stronger adaptation strategies such as migration also reduce welfare losses; in Brazil poverty rates increase by only 2 percent if migration strategies are accounted for (3.2 percent otherwise).

Similar effects are found if changes in the variability of climate events are explored (instead of changes in average weather elements). In Indonesia (Skoufias, Essama-Nssah and Katayama, 2011), a decrease in rainfall in the 90-day period after the monsoon is associated with a 14 percent decline in per capita expenditures other than food. In the Philippines, climate variability, and in particular negative rainfall shocks, reduce household expenditures on food (Balisacan *et al.*, 2011).

Felkner, Tazhibayeva and Townsend (2009) employ a multistage plant development (for planting, growing and harvesting) and an economic model to study the impact of climate changes on rice yields and on income, respectively, for farmers in Southeast Asia. Climate impacts are considered with the use of two possible scenarios regarding changes from neutral to mild or high greenhouse gas emissions. One of the major results of this research suggests that, while yields decline significantly in both models, under both scenarios, for a significant proportion of the sampled farmers, household income is not affected apart from the case of farmers who experience absolute crop failures and are poor. This result indicates, according to the authors, the inability of poorer households to adapt.

Using vulnerability analysis, Karfakis *et al.* (2011a) analysed a sample of 1 242 farming households from Nicaragua. The authors used the daily per capita value of food consumption (an indicator approximating household food security) as a function of several variables representing households' demographic and social characteristics, asset holdings, liquidity constraints, access to infrastructure and geographical location. Along with a household's own capacity to cope with shocks or manage risks (through the use of own assets, farm inputs, participation in producers organizations, etc.), safety nets in the form of government and non-government assistance programmes are employed to account for the impact of social protection programmes. Climate changes are accounted as the proportion of temperature increase (or decrease) during the survey year relative to the long-run average temperature at the municipality level.

This analysis employs a model that studies the direct impact of temperature changes on agricultural productivity and farm income (direct impact) and, through this direct effect, the impact on food consumption and future food security. Despite social or household

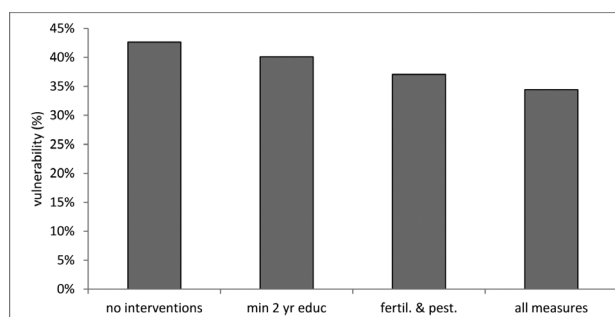


Figure 6. Vulnerability to food insecurity declines with appropriate adaptation

Source: Karfakis *et al.* (2011a).

level options, this research shows that the impact of global warming affecting farmers' consumption through land productivity is substantial.

The results also provide evidence regarding the choice of appropriate policy instruments that would significantly help in reducing household vulnerability. As shown in Figure 6, vulnerability under climate change and without

any adaptation is significantly high (there is an average probability of 42 percent for a household to become food insecure in the near future). Universal access to minimum levels of education and improved agricultural practices through the wider application of pesticides and fertilizers are able to reduce some part of this vulnerability. Jointly these adaptation measures reduce the vulnerability probability to 36 percent on average.

POLICY OPTIONS AND RECOMMENDATIONS

A wide range of policy messages emerge from the assessment of this preliminary evidence and other relevant knowledge sources that discuss the coping and risk management challenges imposed on households by the climate changes and other global trends. Suggested policy measures formulate a comprehensive framework that incorporates the conjoint promotion of what is frequently called **climate-smart agriculture** (Lipper *et al.*, 2010) along with radical progress in **agricultural innovation systems** (World Bank, 2012). This framework involves the close partnership of private and public sectors under a global umbrella of food security governance that tries to accommodate the agenda of challenges at local level along with multilateral solutions.

Identifying vulnerable populations is not a straightforward task. Initially and in order to address the effects of climate change, the development community and national policy-makers should not necessarily (or only) restrict their attention to addressing the needs of farmers. Farmers, especially those integrated into markets, in general are expected to benefit from the higher crop prices brought about by the adverse impacts of climate changes on yields as well as from the increased demand for alternative uses of crops (e.g. biofuels). It is not, however, straightforward that the higher revenues along with the higher costs of most inputs will generate sufficient profit margins for farmers to cover their basic or other needs. Moreover, it is not clear how these revenues will be distributed across the diverse spectrum of farmers in developing regions.

Major attention should be paid to net buyers of food. If, however, net food producers in temperate or tropical regions eventually benefit from projected trends in climate, demographic changes and other trends, then the vulnerable groups most in need for support are the net buyers of food in urban as well as in rural areas. In that case, mostly semi-skilled or unskilled wage earners in different sectors including agriculture are expected to face

severe food insecurity challenges especially in view of the high population pressures – urbanization trends that are already being felt and are expected to increase in the future.⁶

At the micro or livelihood level, adaptation practices to changes in average and variability of the climate in different localities remain the principal policy priority, especially for farmers in rural areas of the developing world. Such policies can be agricultural-specific, which try to increase the efficient use of available resources and products while integrating sustainability features. In this case, improved management of water resources,⁷ extension services, efficient use of fertilizers and pesticides (reducing overuse if needed), diversifying the crop mix,⁸ sustainable practices in extensification and intensification of arable agricultural land, reducing the wastage of food crops through better management of stocks and household consumption are examples of adaptation practices that should be promoted across the board. In this way, the natural reproductive rate of environmental resources will likely be sufficient to cover the rates of their use, also satisfying the needs of current and especially future generations as the very meaning of sustainability signifies.

Policy measures beyond the agriculture sector are also important. On the other hand, not necessarily agricultural-specific policies are always required to address the nexus of development challenges that rural areas are constantly subject to. Investments in infrastructure, the development of credit markets, diversified income sources, policies to increase the general level of human and physical capital, improvements in access to health services and the management of climate-related or other diseases, access to a wider pool of assets and resources, addressing critical institutional constraints and other standard development prerequisites are able to support both farmers as well as economy-wide challenges in the face of climate trends.

Safety nets for vulnerable groups remain key policy priority. For farmers that are not able to adapt and benefit even when the sector's prospects improve, then safety nets supporting their production and agricultural supply as well as their consumption patterns (if those are severely threatened) are needed, and may entail distribution of food or other consumable goods if necessary. In this case, exit from the agriculture sector can be expected, especially when contemporaneous development efforts in the economy as a whole turn out to be successful. Safety nets are equally important for vulnerable groups not working in agriculture (urban or rural poor) that spend a significant share of their income on food.

⁶ Research indicates a series of channels through which overpopulation and associated changes in the demographic structure (e.g. increasing life expectancy) of the populations may affect welfare and food security. However, the most important ones refer to the fact that population growth dilutes capital per person, while congestion in the use of natural resources and fixed inputs, such as land and the environment, will further challenge food security. Moreover, it is expected that larger population increases and any resulting food insecurity concerns will take place in poorer countries rather than in richer ones. The population of Africa will increase tenfold between 1950 and 2050 while several developed countries already face population growth rates that approach zero. On the other hand, many of the African and other developing countries rely heavily on exhaustible natural resources. Under certain assumptions halving the population of a poor country that earns about 30 percent of their income from exports of minerals or energy would increase per capita incomes by 25 percent. But investments from richer countries directed to poorer ones, among which the income differences are more than twentyfold, would have much more positive and sustainable benefits.

⁷ Kurukulasuriya *et al.* (2006), using survey data from several sub-Saharan countries, show that in areas where irrigation systems are already applied increased temperatures may be able to generate increases in crop yields.

⁸ Niggol Seo (2010) estimates that land values in Latin America may fall by only 10 percent in the case of a mixed crop system relative to a –20 percent decline in the case of farms that specialize in the production of a small number or a single crop.

Exit from the agriculture sector should be a crucial policy concern. The reductions in the relative importance of agriculture in national GDPs, as well as the reduction of the agricultural labour shares, remain uniformly observed empirical regularities along the development transition paths of the economies so far. If this remains the case in the face of future climate and other trends that may improve (but not enormously) the prospects for agriculture, then policies to facilitate the exit from the sector and the entry into the manufacturing and the services sectors should be set in place (e.g. policies that facilitate labour mobility and investments in other sectors).

Technical innovations (research and development) in agriculture are required. Finally, from a policy point of view that goes beyond the household level, it always remains necessary to innovate by investing in research and development towards technologies that will modify the properties of crops, increasing their heat tolerance and drought resistance, as well as the properties of land in order to cope with declining yields and overconsumption of nutrients, in different agro-economic zones. At a similar level, other types of policies regarding the mitigation of climate change remain highly relevant in trying to reduce the sources of greenhouse gases or increase their sinks.

Lifting organizational constraints in agricultural markets can increase food efficiency savings. It has to be noted that innovations in agricultural systems are required – but not only in order to address technical issues and constraints. They should also resolve organizational bottlenecks starting at the production level, through the marketing of crops and greater distribution channels until final consumption so that efficiency gains are maximized (e.g. minimize storage times, efficient transportation channels and wastage across the value chains). In addition, information acquisition and dissemination solutions are important factors that contribute not only to exploiting profit opportunities but also to facilitating adoption of technologies, especially new ones that enhance greener features. Innovation systems are a cross-cutting issue that applies both at macro and micro levels.

CONCLUDING REMARKS.

The present paper provides a review of the existing evidence regarding the impacts of climate change on household level welfare as measured either by changes in poverty, in food security, in the value of farm assets (e.g. land), in income, consumption or health outcomes. From this review, the impacts, even though they vary, are usually expected to undermine further the welfare position of poorer farmers and net buyers of food both in rural and urban areas.

The paper further suggests how analytical methods (vulnerability and resilience analysis) that are being tested in FAO can assist in filling part of the knowledge gap existing in the study of these impacts. Given the ability of the methods to model the channels through which climate changes are transmitted to households and affect their welfare, adaptation weaknesses can be identified with relative confidence and validate policy support in building household resilience.

It is a key message of the present work that building knowledge on the expected impacts of climate change at the household level has to be systematically promoted. An FAO pilot study on vulnerability to food insecurity from climate changes in Nicaragua (Karfakis *et*

al., 2011a) assists in describing analytically a relatively comprehensive chain of logical events regarding the impacts of climate change for farm households. A multilevel approach including this type of analysis is implemented by the Climate Energy and Tenure (NRC) and Agricultural Development Economics (ESA) Divisions of FAO, in the context of a project funded by the Ministry of Agriculture, Fisheries and Forestry (MAFF) of Japan, in the Philippines and another country of the Asian Pacific Economic Cooperation (APEC).⁹ A relevant project led by ESA Division, co-funded by the European Commission (EC) and FAO, is also trying to address climate change constraints on household food security and promote climate-smart adaptation practices in Malawi, Zambia and Viet Nam.¹⁰ The principal objective of both projects is to integrate climate change-relevant policies effectively into agriculture sector strategies.

All preliminary evidence suggests that adaptation-enhancing practices will be the most important policy option in smoothing the food security and poverty impacts of climate change of affected households including farmers. Such options include both practices that have to promote a more efficient use of available resources and inputs (i.e. climate-smart agriculture practices) along with the promotion of developmental objectives (e.g. universal basic education).

Nevertheless, the obligations for governments and the international development community, in partnership with the private sector, to adopt macro-level coping strategies should not be neglected. These top-down responses are absolutely necessary to enhance the capacity to confront the challenges that result from climate change, demographic trends and the exhaustive use of natural resources, and manage with what currently looks like the end of agricultural productivity growth that may be approaching.

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⁹ The project is entitled “Assessments of Climate Change Impacts and Mapping of Vulnerability to Food Insecurity under Climate Change to Strengthen Household Food Security with Livelihoods’ Adaptation Approaches (AMICAF)”.

¹⁰ The project is entitled “Climate Smart Agriculture: Capturing the Synergies between Mitigation, Adaptation and Food Security”.

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