AN EMPIRICAL STUDY OF CLIMATE CHANGE EFFECTS AND AGRICULTURE VULNERABILITY

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CONCLUSIONS

This review describes that due to rapid globalization, vulnerability in different areas affects human life. With rapid population growth, securing the inherent vulnerability of this relationship, whether social, economic, or environmental, has to be central to efforts to achieving sustainable development. The vulnerability of agricultural systems varies with geographic location, time, socioeconomic conditions, and environmental resources. The capacity to mitigate and to adapt to climate-change impacts is strongly related to the future development paths. The socioeconomic and, even more so, the technological characteristics of different futures strongly affect emissions, hence the extent and pace of the impacts of climate change, as well as the capability of societies to adapt to and mitigate climate change. The presented review gives a brief idea about empirical analysis of climate change and agricultural vulnerability and how it affects human life.

ABSTRACT

The effects of climate change on agriculture range from the benefits of higher carbon dioxide concentrations and expanded thermal limits to increased frequency and magnitude of floods and drought. At the global level the range of mean climatic changes are not expected to significantly alter food production, and there is sufficient capacity in production systems to adapt to the new climates. However, most assessments suggest that the tropics and sub-tropics will suffer from increased stresses. Developing countries that are already food insecure may be the most vulnerable. The implications of climate change for extreme events – especially long-term drought – are not well characterized at present. The most effective adaptive strategy is likely to be to reduce vulnerability to present climatic variations and promote resilient sustainable development. An uncertainty in both magnitude and direction of climatic impact, a key issue is agriculture vulnerability to possible climate change. Vulnerability is used to mean the potential for negative consequences that are difficult to ameliorate through adaptive measures given the range of possible climate changes that might reasonably occur.

INTRODUCTION

Climate is the primary determinant of agricultural productivity. Given the fundamental role of agriculture in human welfare, concern has been expressed by federal agencies and others regarding the potential effects of climate change on ag-

ricultural productivity. Interest in this issue has motivated a substantial body of research on climate change and agriculture over the past decade. Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems (*Adams et al., 1998*). However, the nature of these biophysical effects and the human responses to them are complex and uncertain. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms. In addition, carbon dioxide is fundamental for plant production; rising concentrations have the potential to enhance the productivity of agro-ecosystems. Climate change may also change the types, frequencies, and intensities of various crop and livestock pests; the availability and timing of irrigation water supplies; and the severity of soil erosion. On the other hand the agricultural sector is critical to social and economic progress, particularly with regard to the eradication of hunger and poverty, the creation of employment and livelihood-earning opportunities, and the generation of trade and foreign exchange earnings. Agriculture is also at the core of environmental concerns over the management of natural resources – land degradation, water scarcity, deforestation, and the threat to biodiversity (*Singh et al., 2006; Singh – Jolankai, 2006*). And yet agriculture has been marginalized, at both national and international levels. Agriculture essentially concerns the relationship between the natural environment and human society. With rapid population growth, securing the inherent vulnerability of this relationship, whether social, economic, or environmental, has to be central to efforts to achieving sustainable development. The focus on people – their scope, rights, capabilities, limitations, and opportunities – has multiple benefits for individuals and society; yet it is the rural population that has to be central in agricultural development efforts.

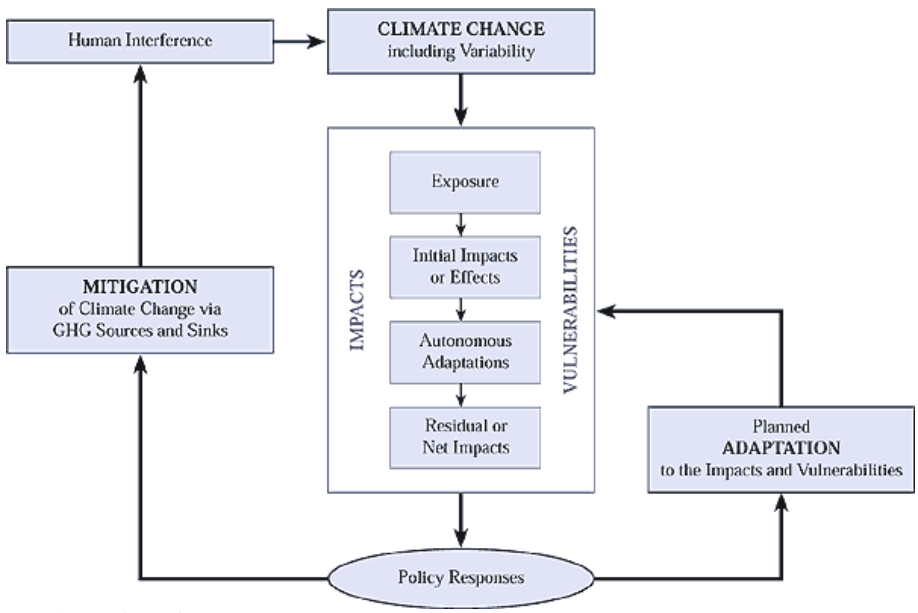
VULNERABILITY AND CLIMATE CHANGE

According to IPCC, vulnerability is defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change. Vulnerability is a function of the sensitivity of a system to changes in climate (the degree to which a system will respond to a given change in climate, including beneficial and harmful effects), adaptive capacity (the degree to which adjustments in practices, processes, or structures can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate), and the degree of exposure of the system to climatic hazards (Figure 1). Under this framework, a highly vulnerable system would be a system that is very sensitive to modest changes in climate, where the sensitivity includes the potential for substantial harmful effects, and for which the ability to adapt is severely constrained. Resilience is the flip side of vulnerability – a resilient system or population is not sensitive to climate variability and change and has the capacity to adapt.

Agricultural vulnerability divided into three major parts e.g. social vulnerability, economic vulnerability, environmental vulnerability.

Figure 1

The inter-relationship between climate change, adaptation, mitigation and their impact and vulnerability issues



Sourche: Smit et al., 1999

SOCIAL VULNERABILITY

Many factors contribute to social vulnerability, including rapid population growth, poverty and hunger, poor health, low levels of education, gender inequality, fragile and hazardous location, and lack of access to resources and services, including knowledge and technological means. And when people are socially disadvantaged or lack political voice, this vulnerability is exacerbated further. Over the next 50 years, the world population is projected to increase by some 3 billion, primarily in the developing countries. This increase in population, mainly in sub-Saharan Africa, South Asia, and the Middle East, is expected to be larger than during the period of rapid growth over the last quarter-century (*IPCC, 2001*). This high rate of growth and agriculture's crucial role in overall rural development mean that in the initial stages this sector will have to absorb many of the new entrants into the rural labor force.

ECONOMIC VULNERABILITY

The economic vulnerability of agriculture is related to a number of interacting elements, including its importance in the overall national economy, trade and foreign-exchange earnings, aid and investments, international prices of agricultural commodities and inputs, and production and consumption patterns. All of these factors intensify economic vulnerability, particularly in countries that are poor and have agriculture-based economies. At the world level, the share of agriculture in total gross domestic product (GDP) in developing countries is about 13%, in contrast to 2% in devel-

oped countries (*IPCC, 2001; Farkas et al., 1997; 2003a,b*).

ENVIRONMENTAL VULNERABILITY

In the 21st century, we now face another, perhaps more devastating, environmental threat, namely global warming and climate change, which could cause irreversible damage to land and water ecosystems and loss of production potential. We cannot be complacent, not when the foundation of human survival, that is, the need for food, may be at risk due to the global-change-induced environmental vulnerability of natural ecosystems. Combating climate change is vital to the pursuit of sustainable development; equally, the pursuit of sustainable development is integral to lasting climate-change mitigation. And the most pressing challenge is to strengthen the social, economic, and environmental resilience of the poorest and the most vulnerable against climate change and variability (*Singh – Jolankai, 2006*).

AGRICULTURE AND CLIMATE

Unmitigated climate change due to increasing greenhouse gases would have global consequences such as adverse impacts on crop yields and water resources, international food insecurity triggered by drought, flooding of lands caused by sea-level rise, and migration of peoples due to environmental changes. Plant systems, and hence crop yields, are influenced by many environmental factors, and these factors, such as moisture and temperature, may act either synergistically or antagonistically with other factors in determining yields (*Parry et al., 2002; EEA, 2004).* Controlled field experiments can generate information on how the yield of a specific crop variety responds to a given stimulus, such as water or fertilizer. However, by their nature, such controlled experiments consider only a limited range of environmental factors. The regions differ significantly, both in the biophysical characteristics of their climate and soil and in the vulnerability of their agricultural systems and people to climate change. An analysis of the biophysical impact of climate changes associated with global warming shows that higher temperatures generally hasten plant maturity in annual species, thus shortening the growth stages of crop plants. Global estimates of agricultural impacts have been fairly rough to date, because of lack of consistent methodology and uncertainty about the physiological effects of CO_2. Climate change scenarios that do not include the physiological effects of CO_2 predict a decrease in estimated national production, but including the physiological effects of CO_2 mitigates the negative effects. Tropical regions appear to be more vulnerable to climate change than temperate regions (*Singh, 2006; Tuba et al., 2004*). In the long run, the climatic change could affect agriculture in several ways

- *productivity*, in terms of quantity and quality of crops;
- *agricultural practices*, through changes of water use (irrigation) and agricultural inputs such as *herbicides, insecticides* and *fertilizers;*
- *environmental effects*, in particular in relation of frequency and intensity of soil *drainage* (leading to nitrogen leaching), *soil erosion*, reduction of crop diversity;
- *rural space*, through the loss of previously cultivated lands, land *speculation*, land renunciation, and hydraulic amenities.

They are large uncertainties to uncover, particularly because there is lack of information on many specific local regions, and include the uncertainties on magnitude of climate change, the effects

of technological changes on productivity, global food demands, and the numerous possibilities of adaptation (*Dobo et al., 2006 a,b; Fekete et al., 2006*). Most agronomists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there will be enough time for *biota* adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum *natural selection* and adaptation. The adoption of efficient new techniques tends to be far from obvious. Some believe *developed nations* are too well-adapted to the present climate. *Developing nations* also would often have extensive social or technical constraints that prevent them from achieving sustainable production (*Fekete et al., 1997; 2003a,b*).

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REFERENCES

(1) Smit, B., I. Burton, R.J.T. Klein and J. Wandel. 1999. 'The anatomy of adaptation to climate change and variability.' *Climatic Change,* forthcoming. – (2) Adams, R. M., et al. (1998), The effects of global change on agriculture: An interpretative review." Journal of Climate Research 11(1): 19-30. – (3) Dobo, E., Fekete-Farkas, M., Singh, M.K., Istvan, S. (2006a), Ecological-Economic Analysis of climate change on food system and agricultural vulnerability: A brief overview. Cereal Research Communications, 777-780, Vol. 34 (1) – (4) EEA (2004), Impacts of Europe's Changing Climate, An indicator-based assessment, EEA Report No 2/2004. http://reports.eea.eu.int/climate_report_2_2004/en – (5) Fekete:Farkas, M., Molnar, J., Szucs, I. (2003b), Socio-economic scenarios of Central and Eastern European agriculture. ACCELCEEC Workshop SZIE, Gödöllő, 9-11 October. – (6) Fekete-Farkas, M, Dobo, E., Singh, M.K., Rounsevell, M., Audsley, E. (2006), Socio-Economic aspect of climate change impact on food production sources and ecosystem in Europe. Cereal Research Communications, 781-784, Vol. 34 (1) – (7) Fekete-Farkas, M, Kamphorst, E., Rounsevell, M., Audsley, E. (2003a), The role of policy in scenarios concerning European agricultural land use change in the coming century, 80th EAAE Seminar, Gent, Belgium, New Policies and Institutions for European Agriculture – (8) Fekete-Farkas, M. and -Audsley, E. (1997), Relationship between farm income and pattern of land use in the Eastern Counties of England, Journal of Hungarian Agricultural Economics, (Gazdálkodás), No.6. pp. 53-65. – (9) IPCC Third Assessment Report (IPCC, 2001), Climate Change 2001: Synthesis Report. Summary for Policymakers. http://www.ipcc.ch/pub/wg2SPMfinal.pdf – (10) Parry et al. (2002). „The consequences of CO2 stabilisation for the impacts of climate change." Climatic Change 53(4): 413-446. – (11) Singh, M.K., Dobo, E., Fekete-Farkas, M., Jolánkai, M. (2006), Coping with climate change: Impacts on agro-ecology and adaptation in Europe. Conference proceeding, Within European Union, Mosonmagyorovar, Hungary 5-7 April, 2006. – (12) Tuba, Z., Bakonyi, G. and Singh, M.K. (2004), Impacts

on Biodiversity. In: Pollution processes in agri-environment. A new approach, Eds.: Láng, I., Kőmíves, T., Jolánkai, M., Akaprint Publishers, Budapest p235-254. – (13) Singh, M.K., M. Jolankai. (2006): Socio-Economic Analysis of global climate change impact on agriculture and diversity of ecosystem in developing countries. International Conference on Economics and Business Management, Yasar University, Izmir, Turkey, June 14-18 – (14) Dobo. E., Fekete-Farkas. M., I. Szucs., M. K. Singh (2006b): „Measurement Techniques Of Effectiveness And Environmental Impact On Agriculture: An Overview". International Conference on Economics and Business Management, Yasar University, Izmir, Turkey, June 14-18