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on
Impact of Climate Change, Pests and Diseases on Food Security and Poverty Reduction

Background Document

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1. Introduction

Poverty and hunger are long-standing items on international and national policy makers' agendas and strategies to overcome both are now once again being intensively discussed in the context of the Millennium Development Goals. Both are largely interlinked since poverty is recognized today both as the cause and the outcome of hunger. Poor people are likely to have less access to healthy, nutritious food, which results in a poor health status and lower labour productivity. These two factors then contribute to perpetuating the vicious cycle of poverty and malnutrition.

Despite considerable improvements in food production over the last 50 years, food security still remains a problem in many parts of the world. FAO's latest estimates for the period 2000 to 2002 show that 852 million people were undernourished. An overwhelming majority of these hungry people is to be found in developing countries (815 million) while, in transition countries, 28 million and, in developed countries, an estimated 9 million people are caloric deficient.

The food security situation of a household is determined by four factors: food availability, access to food, stability of supply and accessibility, and the degree to which food is nutritious and safe and can therefore be utilized. Food availability depends, first and foremost, on the actual production of food, which is influenced by agro-ecological production potential as well as by available production technologies and input and output markets. Food aid and food stocks further determine the supply of food within a region or country. Whether a household or a person is able to access food is determined by the income level, unless the household produces the food itself. Also, the structure of the food supply chain, together with market and transport infrastructure, is an important additional factor. The stability of access to food depends on a number of political and economic factors, such as the stability of the political system and overall poverty levels. But measures to reduce food production variability also contribute to stability in access to food.

All of these diverse key determinants of the food security situation of a household or a nation are influenced by a wide set of socio-economic and bio-physical driving forces. This paper focuses on three of these, namely climate change, animal disease and plant pests. We have concentrated on their implications for food security, but have also given consideration to their impact on human health, as this is another important factor determining human well-being/poverty levels.

2. Climate Change and Food Security

There is strong scientific evidence that global climate is changing and that the social and economic costs of slowing down global warming and of responding to its impacts will be considerable. However, there remain considerable uncertainties as to when, where and how climate change will affect agricultural production. Even less is known about how climate change might influence other aspects that determine food security, such as the accessibility of food for various societal groups and the stability of food supply. Not only are changes in temperature and precipitation, as well as an increase in extreme weather events, likely to change food production potential in many areas of the world, but they also have the potential to disrupt food distribution systems and their infrastructure or to change the purchasing power of, for example, flood victims.

The projected climate change will result in mixed and geographically varying impacts on crop production. The Food and Agriculture Organization of the United Nations (FAO), in collaboration with the International Institute of Applied Systems Analysis (IIASA), has developed the Agro-Ecological Zones (AEZ) methodology, a worldwide spatial soil and climate suitability database. The AEZ approach has been used to quantify regional impacts and geographical shifts in agricultural land and productivity potentials, and the implications for food security resulting from climate change and variability. The analysis indicates that, on average, industrialized countries stand to make substantial gains in production potential, while developing countries are expected to lose.

In the developing world, climate change would lead to an increase in lands that are arid and lands with moisture stress. In Africa, for instance, there are 1.1 billion hectares of land with growing period of less than 120 days. Climate change could, by 2080, result in an expansion of this area by 5-8 percent, or by about 50 - 90 million hectares, FAO said.

The FAO/IIASA study indicates that the developing world would experience an 11% decrease in cultivable rainfed land, with consequent decline in cereal production. Sixty-five developing countries, representing more than half the developing world's total population in 1995, will lose about 280 million tons of potential cereal production as a result of climate change. This loss, valued at an average of US$ 200 per ton, totals US$ 56 billion, equivalent to some 16% of the agricultural gross domestic product of these countries in 1995. Some 29 African countries face an aggregate loss of around 35 million tons in potential cereal production. In the case of Asia, the impact of climate change is mixed: India loses 125 million tons, equivalent to 18% of its rainfed cereal production; China's rainfed cereal production potential of 360 million tons, on the other hand, increases by 15%. Among the cereals, wheat production potential in the sub-tropics is expected to be the worst affected, with significant declines anticipated in Africa, South Asia, and Latin America. Of course, the above-mentioned estimates refer to potential cereal production. Changes in actual cereal production are more difficult, if not impossible, to assess, but the changes in production potential indicate an increasing stress on resources induced by climate change in many, already hard-pressed, developing countries.

The industrialized nations will see significant potential for expansion of suitable land and increased production potential for cereals only when considering the use of "new land" at high latitudes. These potential increases are mainly located in North America, Northern Europe, the Russian Federation, and in East Asia. The positive growth in cereal production potential in the northern hemisphere will tend to buffer the impact of anticipated production shortfalls in the South; hence the impact of climate change on global cereal prices is expected to be moderate. But the distributional effects overall will be negative for the developing world.

Alterations in the patterns of extreme events, such as increased frequency and intensity of droughts, will have much more serious consequences for chronic and transitory food insecurity than will shifts in the patterns of average temperature and precipitation. These rainfall deficits can dramatically reduce crop yields and livestock numbers in the rainfed production systems so common in the semi-arid tropics. Frequent localized increases in food prices could be expected. Subsistence producers growing orphan crops, such as sorghum, millets, etc, could be at the greatest risk, both from a potential drop in productivity and from the danger of losing crop genetic diversity that has been preserved over generations. Humid areas are also vulnerable to climate variability. They can suffer from changes in the length of the growing season and from extreme events, such as tropical cyclones. Food insecurity and loss of livelihood would be further exacerbated by the loss of cultivated land and nursery areas for fisheries through inundation and coastal erosion in low-lying areas of the tropics.

Climate change impacts on agriculture could increase the number of people at risk of hunger. The impact of climate change on food security will be higher in those countries with low economic growth potential that currently have high malnourishment levels. In some 40 poor, developing countries, with a combined population of 2 billion, including 450 million undernourished people, production losses due to climate change may drastically increase the number of undernourished people, severely hindering progress in combating poverty and food insecurity. These low-income, food-deficit countries often do not have the resources to finance food imports in order to fill the gap in requirements. Some of the severest impacts seem likely to be found in the currently food-insecure areas of sub-Saharan Africa, which are the least able to adapt to climate change or to compensate for it through increased food imports.

Land-use changes and the development of improved bioenergy systems that have already been identified as important means of achieving sustainable rural development among small and poor land users have significant potential to contribute to climate change mitigation through sequestration and carbon substitution. Results from the empirical studies of carbon sequestration and bioenergy efficiency indicate that there is considerable heterogeneity in the opportunity, costs and sequestration/substitution productivity over varying land uses and agro-ecological zones. Thus, there is considerable variation in the returns to carbon offsets for poor producers. Carbon emission offset payments could serve either as a means of overcoming financial barriers to reduce the lag time between expenditures and returns in the adoption of perennial cropping systems, or for other measures to reduce vulnerability to climate change and ways of promoting adaptation of production systems and society to climate change impacts. In other cases, carbon offset payments might offer a means of diversifying incomes, allowing producers who are operating traditional pastures to obtain a higher source of income by refraining from deforesting to expand pasture area, or moving into the production of bioenergy crops.

FAO, in close cooperation with others, will continue to monitor the relationship between climate change and food systems. As more data becomes available and policies and research lead to further action at the local level, it is hoped that measures to mitigate and adapt to climate change will reduce vulnerability of the rural poor and open up new opportunities for development and food security.

3. Animal diseases and issues of concern

Climate change is only one of several ‘global change’ factors driving the emergence and spread of diseases in livestock and the transfer of pathogens from animals to humans, others being changes in the structure of the livestock industry, in breeding and husbandry practices and in international trade in livestock and animal products. FAO’s EMPRES - Livestock Programme (EMPRES - Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases) has been focusing on the prevention and control of

Transboundary Animal Diseases (TADs) since its inception in 1994. The initial emphasis was on the Global Rinderpest Eradication Programme (GREP). This strategy has paid off, given that today the disease is thought to have been eradicated from the entire Asian continent, whilst in Africa Rinderpest infection - if still present – is believed to be confined solely to the Somali ecosystem, comprising an area common to Somalia, northern Kenya and south-eastern Ethiopia. The success of GREP is unparalleled in the history of international animal health.

A second disease, against which FAO and its international, regional and national partners have achieved considerable success, is Foot and Mouth Disease (FMD). The European Commission for the control of foot and mouth disease (EUFMD), with its Secretariat hosted by the FAO Animal Health Service, focuses on FMD incursions originating from the Eurasian ruminant 'street', i.e. from the intense movements of ruminants from southern Asia to the eastern Mediterranean basin. FAO is using partnership arrangements in order to step up prevention and control of FMD in Turkey, the Middle East and Central Asia. Similarly, the World Organization for Animal Health (OIE) assists concerted FMD control in Southeast Asia; FMD control programmes are also in place in the Americas, with support provided by the Pan-American Health Organization (PAHO) and others.

Despite the above progress, the overall situation has deteriorated over recent years; the heavy social and economic impact of general TADs spread has become a matter of worldwide concern. Losses brought about by epidemics of FMD, Bovine Spongiform Encephalopathy (BSE), Classical Swine Fever (CSF) and, most recently, Highly Pathogenic Avian Influenza (HPAI) have run into tens of billions of US dollars with, in addition, considerable risk of an emerging human-to-human transmissible virus in the case of HPAI. Elsewhere in the world, TADs spread and persistence have made it difficult to start or consolidate a sizeable, viable livestock industry able to meet the rapidly expanding demand for meat, dairy and eggs.

Worst hit by TADs is the African continent where progressive spread of Contagious Bovine Pleuro-Pneumonia (CBPP), African Swine Fever (ASF), Newcastle Disease (ND) and also FMD, constrains the development of the livestock sector. Moreover, a number of infections also pose a threat to human health. The most noteworthy example is Rift Valley Fever (RVF) which has also spread into the Arabian Peninsula. Ruminant livestock trade across the Greater Horn of Africa, greatly reliant on exportation of live animals to Arab countries, has collapsed as a result.

HPAI or bird flu has swept across east and Southeast Asia and has left a trail of over 130 million chickens, ducks and other poultry dead or culled. Whilst there has been retraction of disease in some countries, HPAI H5N1 virus infection persists and may have become endemic in China, Thailand, Viet Nam and Indonesia. The AI situation in many countries is not fully clear but is believed to remain fluid. HPAI evolution can be, at least partly, understood on the basis of the profound environmental and social changes taking place in Asia. Demographic factors, increase in trade and traffic, agricultural intensification, land use change, climate change and other factors all contribute to increased epidemiological instability. The explosive poultry and pig production increases may have played a role in the evolution, emergence and spread of the pathogen.

Migratory birds have been identified not only as culprits in the spread of HPAI but also as the primary amplifying host in a bird-mosquito-bird cycle spreading West Nile Virus (WNV) to Northern America and elsewhere, including across south and east Asia. Dengue Fever has been on the increase in Asia for at least half a century. Unprecedented population growth, increased human mobility and lack of mosquito control have contributed to epidemic activity. Severe Acute Respiratory Syndrome (SARS) was caused by a previously unrecognized animal corona virus that found its way to the "wet markets" in southern China and adapted to become a virus readily transmissible to humans. International travel provided a local outbreak with the opportunity to achieve global dimensions. Because most recent emerging infectious disease threats have a zoonotic origin, much more attention needs to be given to the evolution of these diseases in livestock and wildlife.

SARS and HPAI have signalled a paradigm shift in international public and veterinary public health. These emergencies highlighted the need for rapid information exchange about unusual infectious disease outbreaks and raised the question of the need for a coordinated global response to emerging infectious disease threats. During the early stages of the SARS outbreak, the World Health Organization (WHO) acted in issuing travel alerts and geographically-specific travel advisories. Following the HPAI outbreak, the Director-General of FAO has established the 'Emergency Centre for Transboundary Animal Diseases' (ECTAD) to enable swift response to transboundary animal/zoonotic disease emergencies. FAO and OIE have together launched a Global Framework for Progressive Control of Transboundary Animal Disease (GF-TAD), endorsed by the FAO Conference in December 2003 and the OIE General Session of May 2004. In addition, FAO has stepped up efforts to more closely align its early warning and information functions and actions with both OIE and WHO.

Perhaps the single most important lesson to be learned from the current TAD spread and emergence is that the world is not fully prepared to respond to this type of crisis. If humanity is to mount a coordinated response to infectious diseases evolving in livestock, including at the interface of animal and human health, it must have the infrastructure necessary to implement action effectively. This requires swift and major action at all levels, starting with the strengthening of the public capacity in terms of animal and veterinary public health in the regions of the world currently worst affected. The immediate aims are to strengthen regional cooperation, surveillance and laboratory networks, information sharing and epidemiological analysis in order to enable the elimination of the disease agent source.

4. Plant pests and issues of concern

Plant pests, which include insects, pathogens and weeds[1], continue to be major constraints to food and agricultural production in parts of all regions of developing countries. Crop losses significantly reduce the amount of food available for human and animal consumption, thus contributing directly to food insecurity and poverty. They also negatively affect internal and external marketing and trade in agricultural products, reduce farmers' incomes, and block poverty alleviation. The control of plant pests still entails substantial use of pesticides, which have side effects on human health and the environment. This is particularly true for relatively poor farmers and farm labourers who cannot afford or demand less toxic compounds, proper application equipment and appropriate personal protection.

A number of pests are found in the whole range to which they are ecologically adapted. An example is leaf rust and stem rust of wheat. When a pest is present in an area (and no official efforts are made for its eradication), it can be considered an established pest.

[1] "pest" is used as defined in the International Plant Protection Convention: "Pest - any species, strain, or biotype of plant, animal, or pathogenic agent injurious to plants or plant products"

Damage by established pests can be severe and may change from year to year. In general, farmers will have and seek ways to deal with such pests, which may, in part be control measures, including cultural controls, host plant resistance, changes in pesticide use including reducing overuse, and in part accepting the loss as economically inevitable. Many such pests are subject to continuing research and development by researchers and farmers. Nevertheless, in extreme years, losses may be very substantial and can result in localized production problems.

Many current pests are not distributed across their whole potential ecological range due to evolutionary, physiological, geographical and historical factors. For example, many European plant species become weeds when introduced in Australia. Many fruitfly species have only a limited distribution when compared with the ecological range they may live in. These pests are of potential quarantine concern in the areas that remain free. A severe case that shows the potential when a pest is able to expand is soybean rust which, after first being reported in 1902 in Japan, has in one century reached all major soybean production areas in every region of the world. Countries collaborate through the International Plant Protection Convention and Regional Plant Protection Organizations to limit the introduction and spread of pests in their territories.

Migratory pests like the Desert Locust have the capacity for rapid multiplication, for long distance migration and can cause extensive crop damage. The build-up of populations depends mainly on favourable ecological conditions in critical breeding areas. Years of outbreaks alternate with periods of inactivity.

Global drivers of plant pest problems include intensification of cropping which provides greater host availability for pests, international trade and food aid that increases the movements of plants and often their accompanying pests, migration and tourism that increase movements of people who carry plant materials, and civil conflict and war, that both increase movement of refugees and military personnel and disrupt phytosanitary control systems at borders.

Climate change as a driver will have different effects on the various types of pests. Based on studies of individual species, climate change may affect: pest developmental rates and numbers of pest generations per year; pest mortality due to cold and freezing during winter months; or host plant susceptibility to pests. When two or more species contribute to a pest problem, as with vectored pathogens or pathogens which cause more severe symptoms in the presence of simultaneous insect damage, the effects of climate change could be expressed through any of these species.

Overall temperature increases may influence crop pathogen interactions by speeding up pathogen growth rates, which increases reproductive generations per crop cycle, by decreasing pathogen mortality due to cold winter temperatures, and by effects on the crop itself that leave the crop more vulnerable. The chestnut blight, originating in Asia and invading North America, expanded more rapidly during warmer years with milder winters, eventually eliminating most of the chestnut trees, and some of their associated insect species in local ecosystems, across the continent. Insects associated with plant disease, such as the scale insects which predispose beech trees to beech bark cankering (*Nectria* spp.) in Northeast USA, may also increase with warmer weather, permitting more severe infection.

For established pests, changing cropping patterns, especially an increase or decrease in the proportion of months in a year that a single host crop is planted, and other climate-related ecological factors, will influence the number of pest generations per year, the severity of a given density of pests in relation to crop growth stage, and cumulative pest impact positively or negatively. This may require relatively rapid adjustments in control measures; it may even make producing certain crops uneconomical, as in the case of the boll weevil on cotton in areas of South America.

FAO's integrated pest management (IPM) programme serves members' efforts to understand and respond to problems associated with established pests. These initiatives build on lessons learned in member countries including on the impact of changing crop-pest relations caused by cropping intensification, expansion of cropped areas, new crops and introductions of crops, pest introductions, and pest population dynamics and evolution, all as influenced by climate change.

Change in ecological conditions associated with climate may increase the suitability of new areas to a potential quarantine pest, which increase their susceptibility to pathogen invasion. The geographical range of a pest or a crop may change along with climate. Then earlier risk assessments that previously formed the basis of trade-permitting or trade-restricting decisions may need to be reconsidered in the context of changing climate.

The Secretariat of the IPPC, based at FAO, works towards closer collaboration among Members, especially developing member countries, including through harmonization of phytosanitary measures, better information exchange, and improved approaches for early warning and rapid response to potential quarantine pests. Changes in ecological conditions associated with climate change should be anticipated, as when pest risk analyses are reviewed or revised in accordance with new climate data.

Climate change may drive ecological changes in the areas where the outbreaks of migratory pests originate, or shift the locations of such areas. The effects of these are difficult to predict; while some migratory pest outbreaks will become less frequent while others become more frequent.

FAO's migratory pests programme, in particular the EMPRES plant component, concentrates on early warning and early control capacity building through better information sharing and strengthening of existing capacity in affected countries. The unpredictability of major migratory pests such as Desert Locusts places a premium on good information analysis and contingency planning. Climate change may likely shift the distribution of breeding grounds of these pests as well as their subsequent movements, necessitating changes in contingency plans. FAO's Emergency Center for Locust Operations (ECLO) is a temporary structure that facilitates rapid response to changing situations during locust upsurges.

Members of FAO have chosen to use the Organization as a means for fostering cooperation to contain and control plant pests through the IPPC, the Rotterdam Convention, regional agreements and regional commissions for locust control. The operational experience and resources available in the regions and at Headquarters will help Members implement these cooperative efforts.

5. Synthesis

Climate change, as well as changing pest and disease patterns, will affect how food production systems operate in the future. This will have a direct influence on food security and poverty levels, particularly in countries with a high dependency on agriculture. In many cases, the impact will be felt directly by the rural poor, as they are often closely linked to direct food systems outcomes for their survival and are less able to substitute losses through food purchases. The urban poor can also be affected negatively because declining food production due to any of these factors will change food prices. This demonstrates how changes in bio-physical factors will ultimately make an impact on humans.

The impact of any of these three factors differs, however. Nevertheless they can all directly affect food availability. With respect to climate change, temperature increases over time will have a longer-term effect because of slow adaptations in cropping systems etc. Increases in frequency of extreme weather events, such as droughts, flooding, or violent storms, are starting to hit food productivity already today. Both pest and disease patterns can also directly reduce productivity. All three factors can also make an impact on the stability of food supplies, one of the other determinants of food security. This can ultimately cause fluctuation in food prices or increase the need to substitute production losses by food imports, which in turn puts a strain on the scarce fiscal resources of developing countries. Climate change in particular affects a third determinant of food security - food accessibility - as the increased incidence of extreme weather events can destroy food marketing infrastructure and reduce income availability of people hit by, for example, a flood.

An additional effect of climate change and changing pest and disease patterns is their direct link to human health, one of the other components of human well-being. Temperature changes, as well as increased air pollution, can enhance human disease patterns, as does the spread of trans-boundary animal diseases with their relationship to pathogens potentially dangerous to humans. Avian flu is the most recent example.

As has been shown earlier, climate change and changing pests and diseases don't just work in isolation from each other, but also interact in various ways. Changed cropping patterns due to increased climate variability, for example, directly influence pest occurrences and thereby change crop productivity. Temperature increases can influence pathogen growth rates or the geographical distribution of livestock in a region. Increased flooding rates change the occurrence of diarrhoeal diseases such as amoebiasis or typhoid.

More research is needed to understand these complex interactions, but it is nevertheless clear that strategies to deal with climate change, as well as with new or changing pests and diseases, have to consist of a mix of direct responses to any one of the factors and responses taking their interactions into account. When designing, for example, an adaptation strategy to climate change, such as new land use practices, scientists and planners also need to be aware of the potential impact on other environmental factors, such as pest and disease patterns. Designing integrated responses, however, is not easy, particularly as decision-making power is often divided between various sectors. For example, dealing with climate change mitigation by modifying the energy sector of a country, may be discussed in the energy or the economic ministry of that country, while dealing with emerging pest problems is handled by the agricultural ministry.

Coherence in response strategies to deal with changes in all three factors is also hampered by the geographical scale and distribution patterns of such factors, which determine the level at which any of these problems are dealt with. Climate change is a *global* problem affecting both land and oceanic areas and having an impact in every country, and therefore global cooperation is required to deal with it. Plant pests can affect vegetation that covers most of the world's land surface areas but tends to be distributed around local centres or foci of concentration and damage. Animal diseases are limited to their host animals, which occupy a fairly small total land area, but centres of concentration and of impact can move across the landscape as the hosts move. Plant pests and animal diseases require more localized or regionalized strategies to manage or control them. Growing worldwide interconnections, due to increased travel and trade, will also mean that greater cooperation for quarantine laws etc. will be desirable in the future.

To begin designing new and coherent responses, existing systems for early warning etc. are a good starting point. However, the analysis carried out using these mechanisms will have to be expanded. It should not just focus on one of the three factors alone, but should take account of the interactions between climate change and pest and disease problems. Therefore, the analysis should monitor additional variables determining these interactions and scientists will have to look for wider frameworks of analysis that include new knowledge in these areas.

This expanded analysis is likely to improve the development of more integrated responses for dealing with the emerging changes in all factors. Understanding the complex web of interactions will help to improve analysis of trade-offs associated with various solutions. As measures to improve one factor can trigger changes in another factor, analyzing which unintended effects are possible and deciding which ones to tolerate or how to deal with them, is likely to enhance the effect of mitigation or adaptation strategies. It is important to note though, that both climate change and changes in pests and diseases are problems that have gained in urgency over the last few decades. Therefore, improving on existing response mechanisms and developing new, more integrated strategies will be one of the key challenges for many countries in the very near future.