2020 VISION

SUSTAINABLE FOOD SECURITY FOR ALL BY 2020

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SUMMARY NOTE

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Title: **The Climate Change — Soil Fertility — Food Security Nexux**

No positives for global warming in the tropics

The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report, states for the first time that the scientific evidence of human-induced global warming is unequivocal and that the latest predictions are much worse than previous estimates. The last 100 years have been the warmest on record, and warming during the last 50 years has a clear human signature. Global temperatures will increase by 1.4–5.8EC by 2100; sea levels are rising and are expected to reach 14–88 cm by 2100, flooding low-lying areas and displacing hundreds of millions people. Rainfall patterns are changing, El Niño events are increasing in frequency and intensity, arctic ice is thinning and tropical mountain glaciers are retreating.

The consequences of these changes assuming concerted global efforts are also dire, according to this report. Agricultural productivity in Africa and Latin America could decrease by 30 percent this century. Severe droughts will occur in Southern Africa, Southeast Asia, the Mediterranean, and the Central Asia. Wetter climates and more floods are predicted for parts of East Africa and Latin America as well as more smoke and haze problems in Southeast Asia and Central America. Higher worldwide food prices are likely to result, negatively affecting the urban poor.

Major changes are also predicted in the structure and functions of critical ecosystems, particularly coral reefs and tropical forests; a geographic spread of malaria, and increased crop pest and disease pressure in wetter climates. The IPCC reports large global economic losses from the already existing global warming: $40 billion in 1999 (25 percent in the tropics).

The adaptive capacity of people to these global changes varies. Countries with the least diversified agriculture, forestry, and fisheries will suffer the most. Africa is considered the most vulnerable region to global warming.

There is a major contrast between developed and developing countries in terms of who causes human-induced global warming and who pays for the consequences. About 75 percent of anthropogenic CO_2 emissions are due to fossil fuel burning, mainly from the North, while the remaining 25 percent is due to changes in tropical land use, especially deforestation. While contributing the least to global warming, it is the developing countries that will suffer the most from it, having the least capacity to adapt. Virtually all the population growth will happen developing countries, and 95+ percent of hungry and poor people live there as well. We need to double food production in developing countries over the next 20–35 years but increasingly variable and changed climates will threaten food production and the natural resource base. Current technologies, policies and institutions are inadequate to meet the challenge of climate change in developing countries.

Adapting crops to thermal stress

Present mean maximum temperatures over much of the tropics where crops are grown are about 34EC. The IPCC Third Assessment Report indicates that temperatures are going to increase throughout the tropics, regardless of changed rainfall regimes. IRRI has recently found that the fertility of rice flowers falls from 100 percent at 34EC to near zero at 40EC, regardless of CO_2 levels in the atmosphere. Any increase in temperature due to global climate change is potentially damaging to rice, to the tune of about 16 percent yield per 1EC degree increase. Similar trends have been found in wheat, maize, beans, soybeans, and peanuts.

Large increases in grain sterility of cereal and legume crops raises a most alarming food security issue, exacerbating the many daunting challenges the world faces to feed itself in the coming decades without considering climate change. The extent of this threat to root and tuber crops, pasture and tree species in unknown to members of the Working Group at this time. If the rates of rice yield decrease due to thermal stress are broadly validated, and assuming the range in temperature increases in the latest IPCC data (0.14–0.58EC per decade) we could face a yield decrease in tropical grain crops of 5–11 percent by the year 2020 and a 11–46 percent decrease by 2050. This project is given top priority because it threatens food security the most.

Soil fertility in Africa

The fundamental cause of low per-capita food production in Africa is soil fertility depletion. Small-scale farmers over decades have removed large quantities of nutrients from their soils without returning them as manure or fertilizer in sufficient quantities. This has resulted in a very high average annual depletion rate — 22 kg of nitrogen (N), 2.5 kg of phosphorus (P), and 15 kg of potassium (K) per hectare of cultivated land per year over the last 30 years in 37 African countries. This annual loss is the equivalent of US$4 billion in fertilizer. The full potential of genetically improved crops cannot be realized when soils are depleted of nutrients. A recent study shows that while the rates of adoption of improved crop varieties have been similar in Asia, Latin America, the Middle East and Sub-Saharan Africa during the last 38 years, such varieties are responsible for 66–88 percent of the crop yield increases in the first three regions but only for 28 percent in Africa. Soil fertility is the likely biophysical reason behind such differences, and therefore is the logical starting point to tackle hunger in Africa.

The traditional way to overcome nutrient depletion is the use of mineral fertilizers. But fertilizers cost from 2-6 times more at the farm gate in Africa than in Europe, North America, or Asia. Spot checks indicate that a metric ton of urea costs about $90 FOB in Europe, $120 delivered in the ports of Mombasa, Kenya or Beira, Mozambique, $400 in western Kenya (700 km away from Mombasa), $500 across the border in Eastern Uganda and $770 in Malawi (transported from Beira).

A new approach

Such gross price distortions have triggered new approaches, most of them combining organic inputs with mineral fertilizers. An approach using natural resources management has been developed by researchers working with farmers during the last decade, and is now being adopted by tens of thousands of African farmers. It consists of capturing nitrogen from the air via biological N-fixation by leguminous tree fallows, utilizing phosphorus from the many small, indigenous phosphate rock deposits of the region, and transferring additional nutrients and carbon with the biomass of nutrient-accumulating shrubs.

Improved fallows. Leguminous trees of the genera Sesbania, Tephrosia, Crotalaria, Gliricidia and Cajanus are interplanted with a young maize crop and allowed to grow as fallows during dry seasons, accumulating 100–200 kg N ha — 1 in 6 months to 2 years in subhumid tropical regions of East and Southern Africa. The quantities of nitrogen captured are similar to those applied by commercial farmers as fertilizers to grow maize in developed countries. After harvesting the wood from the tree fallows, N-rich leaves, pods and green branches are hoed into the soil prior to planting maize at the start of a subsequent rainy season. This aboveground litter plus the tree roots decompose, releasing nitrogen and other nutrients to the soil. Maize yields increase by a factor of 2–4 times as nitrogen deficiency is overcome. Farmers are now establishing tree fallow-crop rotations, one year of trees followed by one crop of maize in bimodal rainfall areas of East Africa, and two years of trees followed by 2–3 maize crops in unimodal rainfall areas of southern Africa. Nitrogen fertilizer applications at the recommended rates produce slightly higher yields than improved fallows but few farmers can afford them.

This approach is economically and ecologically sound and fits well with farmer customs and work calendars (no surprise, because it was developed together with farmers). High net present values and returns to labor have been recorded with the new fallow-crop rotations. Leguminous fallows capture nitrogen from the air mostly during the dry seasons when there are few viable alternative land uses. In addition tree fallows provide multiple benefits such as producing in-situ fuelwood, capturing leached nitrates from the subsoil, recycling other nutrients, controlling the parasitic weed Striga, improving soil physical properties, and sequestering carbon.

Indigenous rock phosphates. While nitrogen deficiency is ubiquitous in African croplands, phosphorus deficiency is widespread in East Africa and the Sahel. In western Kenya, 80 percent of the smallholder land used for maize is extremely deficient in phosphorus and many of the soils have a strong P-sorption capacity. Utilizing indigenous rock phosphate deposits provides an alternative to imported superphosphates. The mild acidity of most of these soils (pH 5–6) helps dissolve high-quality rock phosphates. Under such conditions direct applications of highly reactive sedimentary or biogenic phosphate rock doubles or triples maize yields 90 percent as efficiently as superphosphates.

Biomass transfers of leaves of the nutrient-accumulating shrub Tithonia diversifolia from roadsides and hedges into cropped fields adds nutrients and routinely double maize yields at rates used by farmers, without fertilizer additions. This organic source of nutrients is more effective than urea when applied at the same N rates, because tithonia also adds carbon that enhances nutrient cycling, increases microbial biomass, decreases P-sorption temporarily and adds other plant nutrients, particularly potassium and micronutrients.

Food security

About 50,000 farm families in subhumid tropical Africa are using various combinations of the three main components with good and consistent results. Farmers and communities report that hunger periods are eliminated when using combinations of these practices, thus achieving household food security and benefitting from a supply of fuelwood produced on farm. Knowledge is being transferred farmer-to-farmer, village-to-village, by community-based organizations and by a multitude of national research and extension institutes, universities, nongovernmental organizations, and development projects.

After the soil's fertility is replenished other factors such as improved crop varieties, integrated pest management, conservation tillage, crop rotations, improved roads, and access to markets, credit and information must come into play, just as it happened in Asia during the Green Revolution.

Poverty reduction

Growing maize in farms of 1–2 hectares can overcome hunger in the household and the aggregate effect could double food production in Africa, but it is unlikely to overcome poverty. After the soil's fertility is replenished however, farmers can begin to take the first steps out of abject poverty by growing vegetables, raising dairy cattle and growing trees that deliver high-value products such as fruits, honey, medicines and high-grade timber which they can sell. Switching from annual crop production to mixed crop-livestock-tree farming is a proven way of asset building. Experience in a poor but market oriented area in western Kenya shows much higher rates of return with tithonia applications on vegetables compared to maize. We have experienced farmers' incomes increasing from US$1 per day to as much as $10.

Health

Anecdotal evidence in western Kenya suggests that those families living on fertility-replenished farms are healthier. The elimination of hunger periods decreases the susceptibility to all sorts of diseases-major and minor. Farm families that are producing milk and other high-value products are also better nourished.

Mitigating climate change

Land-use change from degraded croplands into integrated tree-crop-livestock farming systems that replenish soil fertility and grow high-value trees result in several positive environmental externalities in subhumid tropical Africa. Most tropical soils are depleted of soluble carbon that microorganisms utilize as their energy source. Organic nutrient inputs enhance nutrient cycling, mineralization rates and the transformation of inorganic forms of phosphorus into more available organic ones. Such agroforestry systems also can sequester large quantities of carbon in the tree biomass and soils, about 1–3 metric tons of C ha — 1 per year which is 5 to 10 times more than what most other agricultural land-use intensification options can do.

Policy needs

The technologies reported here are effective and more appropriate to current African conditions than those used during the Green Revolution. Replenishing soil fertility in Africa is the key entry point towards eliminating hunger on this continent. It is a necessary but not sufficient condition, and must go hand in hand with improving health, education, governance, infrastructure, and trade. Large and sustained investments are necessary to capitalize and extend these promising leads. Specifically:

- Breed for tolerance of grain fertility to heat stress;
- Implement development projects to scale-up fertility-replenishment practices from tens of thousands to tens of millions of African farm families. Governments should focus on two key bottlenecks-the supply of quality tree germplasm grown in community-based nurseries, and increase the awareness and knowledge of such technologies;
- Develop policies that reduce the disparity between world market and the prices paid by African farmers for mineral fertilizers. Their use must increase drastically and they should be applied together with organic inputs.
- Improve transport and marketing infrastructure for high-value products that are the natural comparative advantage of smallholders in Africa.
- Implement carbon offset projects with farming communities that can help mitigate global climate change in ways that allow farmers to benefit financially from this global environmental service while at the same time eliminating hunger and decreasing poverty.

Investments in integrated community development projects that combine the agriculture, health, and education sectors have a greater chance of success than those that focus on a single sector as the problems are interrelated.