4. COMBATING HUNGER AND POVERTY IN THE TROPICAL DRYLANDS OF ASIA AND AFRICA

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ABSTRACT

The tropical drylands are characterized by extreme rainfall variability, recurrent and unpredictable droughts, flooding, warm temperatures and a fragile natural resource base with inherent low fertility soils. Crop production is low and over 45% of the world's hungry people live in these regions. Climate change, growing populations, poor development infrastructure, increasing land degradation and water scarcity make achieving food security in the tropical drylands a daunting challenge. However, success stories from throughout the region show that under optimal water, land and crop management, crop yields and farmers incomes can be substantially increased. Innovative research and development strategies that address natural resource management carried out in partnership with farmers and other stakeholders, and integrating policy, marketing and support services, can address problems of poverty, food insecurity and environmental degradation and bring prosperity to the tropical drylands.

INTRODUCTION

The semi-arid tropics or tropical drylands span 6.5 million square kilometers covering over 55 countries and are home to more than 2 billion people (Figure 1). Over 45% of the world's hungry and more than 75% of its malnourished children live in this region (Wani et al. 2009). The majority of poor live in rural areas and depend on agriculture for their livelihoods.

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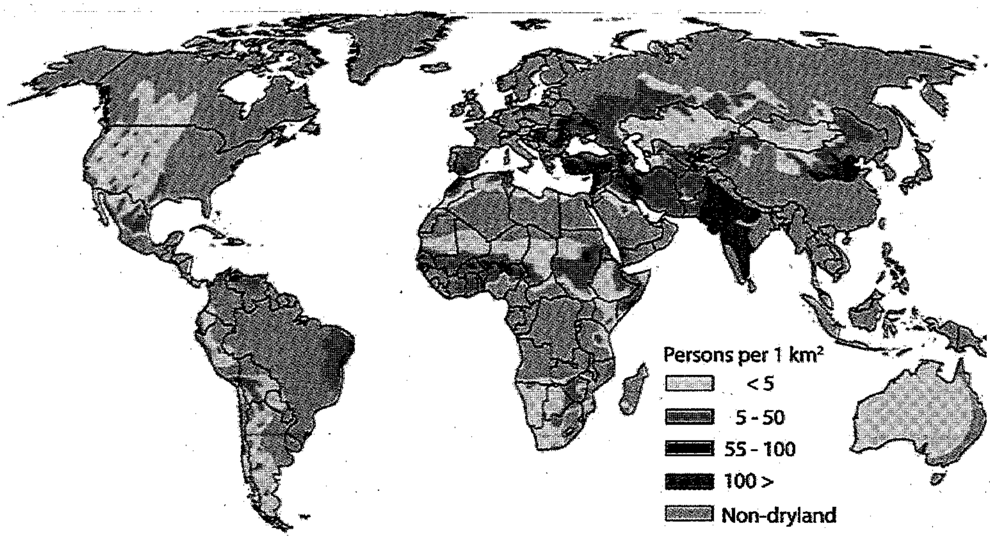
The tropical drylands have a challenging and inhospitable terrain where agriculture is risky. Characterized by extreme rainfall variability, recurrent and unpredictable droughts, flooding, warm temperatures and a fragile natural resource base with inherent low fertility soils, the rising perfect storm -- a confluence of climate change, desertification, biodiversity loss, price rise, and mounting poverty and population -- further threatens to disrupt the lives of the poor who depend on agriculture for survival.

Figure 1. The semi-arid tropics



With an annual linear rate of population growth of 1.6% in the drylands, there will be about 115 million more mouths to feed between now and 2020; 46 million in Africa's drylands and 69 million in Asia's. The expanding population and accelerating use of natural resources is resulting in increased natural resource degradation. Achieving food security under these conditions is a daunting challenge, but it also represents an opportunity. As Dr Norman Borlaug, a central figure in the 'Green Revolution' said, "The yield potential is there, but you can't eat potential."

Agricultural production in the tropical drylands is predominantly rainfed. Rainfall generally occurs in short, torrential downpours and much of this water is lost as surface runoff, evaporation or deep drainage (Pathak et al. 2009). Rainwater use efficiency is therefore low (35-45%) and over the long term, the runoff results in extensive loss of precious, nutrient-rich topsoil. In addition, groundwater levels in the tropical drylands are being depleted and most rural rainfed areas are facing general water scarcity and drinking water shortages during the summer months (Pathak et al. 2009).

In temperate, humid or subhumid regions of the world, rainfed agriculture produces very high yields (5-6 t/ha), but in farmed lands of the semi-arid regions, yields average only 1-1.5 t/ha (Wani et al. 2009). Drought, dry spells and land degradation are the main causes of low crop production and poverty in the semi-arid regions. Droughts cause crop failures and short dry spells during the growing season reduce crop yields. The high risk of losing part or all of a crop makes farmers unwilling to invest in inputs and land management and the resulting poor use of agricultural lands results in increased soil loss due to wind and water erosion, nutrient depletion, salinization, loss of vegetation cover and reduced biodiversity.

Agriculture in the semi-arid tropics has long been viewed with pessimism and hopelessness. Tropical dryland areas are usually seen as resource-poor and perennially beset by shocks such as drought, trapping dryland communities in poverty and hunger, making them dependent on external aid. However, dryland farmers are ingenious and resourceful and recent yield gap analyses carried out for major rainfed crops of the region revealed that farmers' current yields were two to four times lower than yields achievable under optimal water and management (Singh et al. 2009a; Wani et al. 2009) (Figure 2, blue columns). By applying scientific innovations backed by adequate policy, marketing and other support services, farmers are able to increase their crop productivity and incomes several-fold, while improving the resilience of their lands and livelihoods. Thus, there is hope of prosperity in the tropical drylands.

MANAGING WATER TO OVERCOME SCARCITY

Given the persistent problems of drought and water scarcity in the drylands, water shortages must be addressed by utilizing natural resource management principles and techniques to improve moisture content, fertility, soil depth, organic matter, and rainwater utilization through watersheds and water conservation and by employing plant breeding and biotechnology research to improve water-use efficiency and drought tolerance in crop genotypes.

In the tropical drylands, seasonal rainfall is generally adequate to significantly improve yields but managing the extreme rainfall variability in time and space is a tremendous challenge (Wani et al. 2009). Rainfall is seasonally variable and characterized by few rainfall events, high intensity storms and a high frequency of dry spells or droughts. Managing water and using it efficiently are the main yield determinants. Droughts result in complete crop failure which cannot be prevented by agricultural water management and must be managed by other means such as food storage, livestock sales or grain banks. Short dry spells occurring during the growing season, however, can be bridged using improved land and water management. Water harvesting, supplemental irrigation and community watershed management are all tools that can lead to improved crop production and local food security.

Water Harvesting

Water harvesting, an age-old practice which collects and stores surface runoff and uses it to irrigate crops during dry spells, can stabilize crop production and alleviate the risk associated with unpredictable rainfall. Water harvesting systems include catchment areas that range from a rooftop to several square kilometers of land where runoff occurs and a storage facility such as a tank or a pond collects and holds the runoff water. Successful implementation of water harvesting requires data on rainfall, soil, relief, cropping systems, and local socio-economic conditions in order to minimize soil erosion, habitat loss and water conflicts (Oweis and Hachem, 2009).

Supplemental Irrigation

Combining water harvesting with effective irrigation technology can result in significant water productivity improvements. Inexpensive and simple irrigation systems have been developed to save labor and optimize the use of water for row crops on small plots (Singh et al. 2009b). For example, Bucket Kits include a simple 20-liter household bucket (often replaced with a polythene bag) attached to a pole at about shoulder-height and equipped with drip tapes to water a kitchen garden or larger Drum Kit systems with a 200-liter drum with lateral lines and micro tubes to irrigate a 125 m^2 plot. Low-head drip irrigation technology using drip tape has proved useful in sloped and uneven fields and has a high water use efficiency. Supplemental irrigation at a rate of 60-80mm doubled and even tripled grain yields in Burkina Faso and Kenya, although the most beneficial effects of the irrigation were obtained only in combination with soil fertility improvements (Rockström et al. 2003).

Community Watershed Development

Management of natural resources at the watershed scale increases food production, improves livelihoods, protects the environment, addresses gender and equity issues and is considered an engine of growth for development of fragile rainfed areas (Joshi et al. 2009). In the past, improved watershed management was generally synonymous with achieving a particular, often single technical objective, e.g. improved forestry, better soil conservation, or the introduction of water harvesting and was initiated and executed with little or no real involvement of farmers. A new approach regards watershed development and management in its entire complexity, where inter-related factors and their interactions are considered with the main objective of poverty alleviation and food security of watershed communities (ICRISAT, 2011). Partnerships draw on expertise from research organizations, NGOs, agricultural universities, and local governments but retain farm households as key decision makers. With the new emphasis on poverty alleviation and food security through appropriate natural resources management, both people and natural resources become the primary focus. Conservation and harvesting of rainwater to augment surface and groundwater, management to improve soil quality (use of fertilizers, crop residues, composting and crop diversification with legumes), wasteland development and tree planting, use of high-yielding varieties, introduction of integrated pest management to reduce pesticide as well as training farmers and other stakeholders in new technologies and approaches are all used together to increase food production in the watershed (Joshi et al. 2009).

Participatory and knowledge-based watershed development programs in Andhra Pradesh, Gujarat, Madhya Pradesh, Rajasthan and other states in India and parts of southern China, northern Vietnam and northeast Thailand have shown that farmer and public investment can provide attractive social returns leading to poverty reduction. The success of the Adarsha Watershed model in Kothapally in Andhra Pradesh, India has attracted farmers, policymakers and development investors (Sreedevi et al. 2004). Income-generating options for the landless and women at Kothapally and other benchmark watersheds have included the setting up of village seed banks through self-help groups; value addition through seed material; product processing such as dhal making, grading and marketability; poultry rearing for egg and meat production and vermi-composting. An average household income of US$ 1066 was generated from crop diversification and other systems in the watershed compared to US$ 734 in the non-watershed, reflecting an increase of 45% due to watershed interventions.

Similarly, the Lucheba watershed in Guizhou province in China saw improved productivity with the adoption of cost-efficient water harvesting structures, farming system diversification and intensification from rice and rapeseed to tending livestock and horticultural crops. Following watershed interventions, mainly growing vegetables and other diversified activities like tending chicks and pigs, the average income of farmers increased threefold, from US$ 462 (before the interventions) to US$ 1538. The development of community watersheds in China and India has resulted in crop yields increasing up to four-fold and incomes rising by 45% and 77%, respectively.

CROP IMPROVEMENT AND DIVERSIFICATION

Sustainable growth in crop production, farm income, food security and environmental protection can be achieved through the development of improved and diversified cultivars, eco-friendly and cost-effective pest management practices, efficient seed supply systems, and commercialization of diversified and alternative uses of crop produce. Chickpea, groundnut, pigeonpea, sorghum and millet are all drought-resistant and nutritious crops that are well-suited to the semi-arid tropics and work is being carried out to increase adoption of improved varieties by farmers through formal and informal seed-supply chains and systems, and to develop institutional mechanisms between public and private sector stakeholders to ensure sustainable demand for public sector-bred improved varieties (ICRISAT, 2011).

Recognizing the potential of agricultural biodiversity and the services it provides will be key to meeting future food needs while maintaining and enhancing the other goods and services provided by agricultural ecosystems, such as clean air and water (Waliyar et al. 2002). Diversification of crops cultivated by smallholder farmers in the semi-arid tropics has the potential to increase household income, create a more nutritious household diet and provide remunerative labor opportunities as well as valuable by-products such as firewood, fibre and fodder. Crop diversification by introducing legumes into rice/wheat fallows pursued in the Indo-Gangetic plains of South Asia, growing medicinal and aromatic plants in partnership with private sector companies and systems diversification through mixed crop-livestock systems have served as coping strategies against risk and also enhanced incomes. Crop residues of chickpea, groundnut, pigeonpea, sorghum and millet are important sources of animal feed throughout the year, notably in the dry months when other feed resources are scarce. Improving the digestibility of such crop residues can have a significant impact on milk production, particularly in South Asia. For example, haulm or stems of a groundnut variety led to a 20% increase in milk yield of dairy animals of farmers adopting the improved variety in Andhra Pradesh (ICRISAT, 2009).

The African Market Gardens (AMGs) concept combines low pressure drip irrigation systems with high-value crop diversification, enabling the commercial integration of fruit, vegetables and trees in the dry Sahel. These small "market gardens" can be tended by women's groups to both increase their incomes and diversify their family's diet, multiplying their annual incomes by several-fold, in some cases more than 10-fold to US$ 1,500 from an area of only 500 square meters.

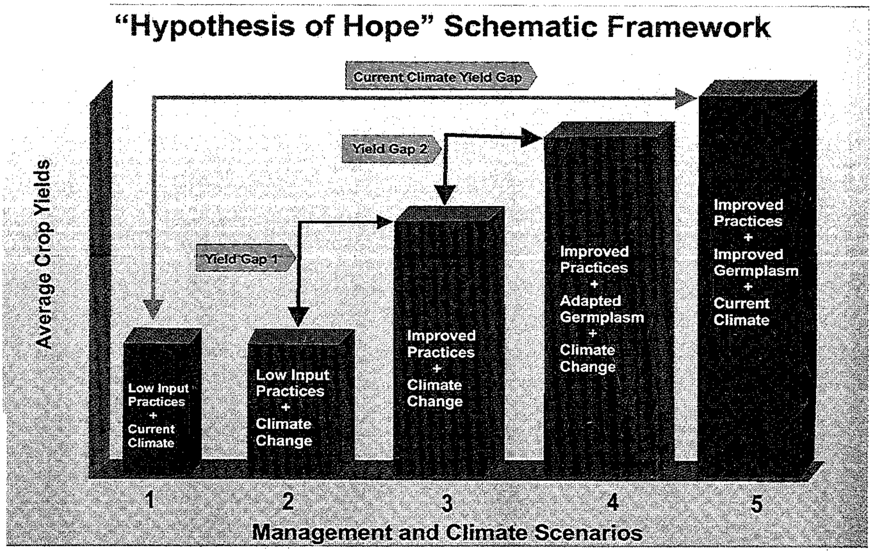
Crop Breeding

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a genebank in India that holds 120,000 accessions of chickpea, pigeonpea, groundnut, sorghum, pearl millet, and six small millets from 144 countries. The collection serves as insurance against genetic erosion and as a source of resistance to diseases and pests, tolerance to climatic and other environmental stresses and improved quality and yield traits for crop improvement. It has distributed over 1.3 million samples to scientists in 144 countries, and 66 accessions have been directly released in 44 countries contributing to global food security. Development of new varieties and cultivars of the crops and their introduction to local smallholder farmers in India has resulted in increased crop production and yields and improved crop quality.

CLIMATE CHANGE

Climate change predictions point to warmer temperatures in the tropical drylands and shorter growing seasons, increased drought frequency and changing rainfall patterns in many regions (IPCC, 2007). ICRISAT studies have generated a "hypothesis of hope" (Figure 2) which provides optimism that the impacts of climate change on yield under low input agriculture are likely to be minimal. The average crop yield grown under the current climate (blue columns), show that a massive yield improvement is possible by improving agronomic practices and germplasm. Even under conditions of climate change (red columns), strong yields are still possible if farmers combine improved practices with climate-adapted crop varieties.

Figure 2. Climate change adaptation in the drylands: ICRISAT's hypothesis of hope



To cope with the impacts of climate change on reduced length of crop growing season, crops that are adapted to heat and high soil temperatures, knowledge and understanding of photoperiod-sensitive flowering, information on genetic variation for transpiration efficiency, short-duration varieties that escape terminal drought and high-yielding and disease-resistant varieties will all be valuable tools to improve crop production. Short-duration chickpea cultivars that can withstand high temperatures, pearl millet flowering at 40+°C and a short-duration groundnut cultivar that escapes terminal drought are some examples of resilient crops for the poor.

LINKING FARMERS TO MARKETS

Developing countries in Asia and Africa are witnessing a fundamental shift in agriculture from farming for household consumption to a more market-oriented production, where consumer-driven supply chains will play a dominant role unlike the erstwhile product-oriented supply chains. Thus, procurement and marketing of agricultural commodities are witnessing institutional innovations like contract farming, bulk marketing through producers' associations, direct marketing, marketing through cooperatives or specialized middlemen and ICT-enabled supply chains that directly link the producer to the end user.

Linking smallholder farmers to input and output markets and other actors along the value chain that include credit agencies, assemblers, wholesalers, transporters and finally the consumer/end user is essential for success. For example, in Malawi, groundnut producers are assured markets through the 100,000-member strong National Smallholder Farmer Association of Malawi (NASFAM), which provides agricultural advisory services for groundnut production.

EMPOWERING WOMEN

The majority of farmers in the dryland tropics are women and therefore it is necessary to engage women as leaders in farmer-to-farmer knowledge-sharing and training activities in areas such as crop management, participatory plant breeding, crop processing, marketing and agro-enterprise development. Helping women's groups to gain access to the seed and skills that they need to grow and export high-value crops improves women's incomes and directly benefits household nutrition. In Niger, for example, a group of 120 landless women in the Dosso region started growing hardy indigenous vegetables in degraded land on a 7 hectare field in June 2006. Micro-catchments (demi-lunes) were built to catch and store runoff rainwater and between the demi-lunes, planting pits were dug to place manure and the plant. The degraded area has grown to 70 hectares of lush and productive greenery. Women are additionally using crops such as a new short-duration okra cultivar jointly developed by AVRDC. At present, 5000 rural women and their households are benefiting from these technologies.

Women also capture most of the profits from market gardens established in Niger since they dominate vegetable production and marketing. Market gardens producing improved tomato, onion and other vegetable varieties have proved highly profitable, giving annual returns of up to US$1,500 from an area of only 500 square meters. For the first time ever, markets in the nation's capital, Niamey, were well supplied with tomatoes in the 2009 rainy season.

ENHANCING IMPROVED SEED AND FERTILIZER AVAILABILITY

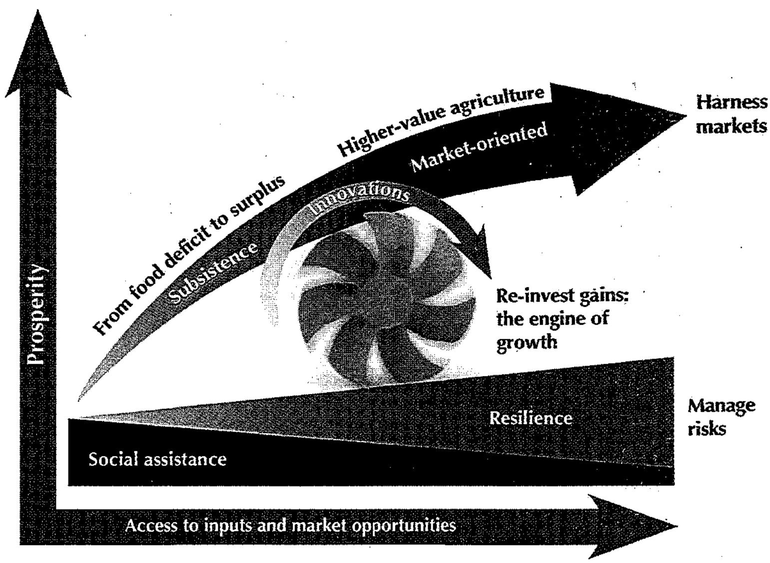
The availability of quality seed is the foundation for food production and productivity and a precursor to crop and food diversification. Although research has developed new stress-tolerant crop varieties that are well-adapted to smallholder farms, many farmers lack access to improved seed and continue to recycle old seed that has been exhausted after generations of cultivation. Yields have remained poor, contributing to food insecurity. To overcome such limitations, it is necessary to develop local seed companies by supporting breeders in national breeding programs to develop and release improved varieties of a range of food crops; establish a network of agro dealers; support new and existing seed companies to produce and market improved quality seed and support seed trade harmonization at the regional level. For example, the West Africa Seed Alliance (WASA) is working towards the establishment of a sustainable commercial seed industry capable of ensuring that small-scale farmers have affordable, timely and reliable access to adapted genetics and traits in high quality seeds and planting materials. Through a baseline survey in the Dosso region of Niger, 22 farmer associations and individual women farmers were identified as local seed producers and traders. They were selected and trained through WASA and today, more 135 farmers (including 86 women) are involved in the seed business. In India, ICRISAT encourages and helps smallholder farmers to go into the production and storage of self-pollinated varieties of legumes since the private seed sector is not active in seed production.

Smallholder farmers often have little access to fertilizers or cannot afford them. Providing small packs of fertilizers of various sizes improves access in two ways: first, it is affordable to many who cannot meet the full cost of the traditional 50 kg bags and, second, it creates convenient access to farmers as the fertilizer can be more easily sent to a depot close to them (Minde et al. 2008). Novel outreach approaches in Africa using mechanisms such as micro-credit, vouchers systems, and precision use of fertilizers are also helping farmers to access and utilize seed to maximize their incomes.

INCLUSIVE MARKET-ORIENTED DEVELOPMENT (IMOD): THE NEW WAY FORWARD

Dryland poverty rates are declining in Asia, but not in sub-Saharan Africa. Analyses by the World Bank and ICRISAT have found that access to markets is key to escaping poverty. Gleaned from its rich knowledge base spanning 38 years in partnership with institutions, strategic studies, long-term village-level studies, as well as global studies by the World Bank, ICRISAT has adopted Inclusive Market-Oriented Development (IMOD) as a guiding framework of its new Strategic Plan to 2020 to empower smallholder farmers to grow their way out of poverty. IMOD is a socio-economic process and a dynamic progression from subsistence towards market-oriented agriculture which will achieve a new level of access to resources, stability and productivity for poor smallholder farmers (Figure 3).

Figure 3. Inclusive market-oriented development (IMOD), the unifying conceptual framework for ICRISAT's Strategic Plan to 2020



IMOD starts by increasing the production of staple food crops, converting deficits into surpluses that are stored or sold into markets. Stored food provides a buffer in times of hunger, and higher incomes make it possible to purchase more food when needed. Income enables the poor to purchase inputs such as seed, fertilizer, labour, tools, livestock, insurance and education. These inputs raise farm productivity and prosperity further and enable another round of investment and productivity growth, creating a self-reinforcing pathway out of poverty. This forms the crux of IMOD.

To pursue this pathway to prosperity, ICRISAT will employ a systems perspective in setting its priorities to ensure that all important issues are addressed holistically. At a macro level, systems thinking allow ICRISAT to study the interaction of various economic, social, political, physical and technological factors influencing tropical dryland agriculture. At a micro level, this perspective is valuable in viewing how things influence one another within a dryland farming system. This perspective enables ICRISAT to plan, implement and evaluate its research programs for optimum impact along the whole dryland agriculture value chain.

CONCLUSIONS

Agriculture in the dryland tropics is predominantly carried out by smallholder farmers on land that has an unreliable supply of water and is nutrient poor. A lack of social services and development infrastructure further restrict farmer incomes and result in extensive food insecurity. There are, however, many tools that the resourceful and experienced farmers of the tropical drylands can put to good use if given the opportunity to participate in community development and capacity building. Water harvesting, supplemental irrigation, providing access to micro-credit, quality seeds and inputs, diversifying crops, developing storage and processing facilities and expertise, and linking farmers to markets will all lead to increased crop production and farmer prosperity. Inclusive market-oriented development (IMOD), a unifying conceptual framework developed by ICRISAT, incorporates all these tools in the planning, implementation and evaluation of its research programs for optimum impact along the whole dryland agriculture value chain. Significant reductions in poverty and increases in food security in the dryland tropics are possible.

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