# Converting Deserts into Oasis

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# Converting Desert Areas into Oasis

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The Alliance of centers of the Consultative Group on International Agricultural Research (CGIAR) and their partners have been engaged in scientific research and development globally to combat drought and desertification. These science-based efforts have made available innovations for the better use of natural resources, and formulation of policies that help people cope with desertification. The results of such an effort have been worldwide, especially for sub-Saharan Africa and South Asia. The research-for-development outputs include breeding crop cultivars for drought tolerance, sustainable soil and water management and natural resource conserving technologies.

The year 2006 was declared the International Year of Deserts and Desertification (IYDD) by the United Nations. During 2006, the Alliance of centers of the CGIAR endorsed a collective initiative termed "Oasis" to redouble efforts to combat drought and desertification in the drylands of the developing world. This communication briefly outlines the objective of Oasis and its research-for-development agenda and experiences in partnership with the United Nations Convention to Combat Desertification (UNCCD).

## The Objective of Oasis

The main objective of creating Oasis was to link, synergize and synchronize the research-for-development activities of the Alliance of centers of the CGIAR in partnership with national, regional, international civil society, and the private sector across the developing world. The Oasis is jointly convened by the International Crops

Research Institute for the Semi-Arid Tropic (ICRISAT) and the International Center for Agricultural Research in the Dry Areas (ICARDA), and linked with the work of the International Centre for Tropical Agriculture (CIAT), International Centre for Maize and Wheat Improvement (CIMMYT), World Agroforestry Center (ICRAF), International Food Policy Research Institute (IFPRI), International Livestock Research Institute (ILRI) and Africa Rice Center (WARDA). The long standing involvement of ICRISAT and ICARDA in the UNCCD process has led to a better understanding and appreciation of the implementation and coordination of the activities to combat desertification in the dry areas and semi-arid tropics among UN member states of the developing world.

Oasis will focus on better understanding of the problem and implementing technologies to arrest land degradation, mitigate drought, restore and stabilize dryland ecosystems; develop policy and institutional options to encourage sustainable land use and increased investments in the drylands; diversify agricultural systems and livelihoods; and share technologies. Based on the initial discussions with the CGIAR centers involved, the specific objectives, as given below, are likely to be firmed up for implementation following further talks with the partners involved:

- Understanding and arresting land degradation
- Drought mitigation
- Restoration and/or stabilization of dryland ecosystems
- Formulation of policy and institutional options to encourage sustainable land use practices, and work for greater investments in dryland agriculture and related activities
- Diversifying agricultural systems and livelihood opportunities
- Sharing knowledge and identify technologies or their components for implementation in the field.

## ICRISAT Experiences in Combating Desertification and Improving Livelihoods

### *Market Gardens in SAT Africa*

ICRISAT is promoting "Market Gardens" in sub-Saharan Africa to generate additional incomes and provide livelihood opportunities to farmers. The market gardens are small plots that are intensively

cultivated and bucket-irrigated to provide vegetables for urban dwellers. They are becoming quite popular and are now a common sight in sub-Saharan Africa. It has been estimated that the investment in African Market Gardens pays for itself in the first year. Thus far, over 100 pilot African Market Gardens have already been established in the Sahel.

Undoubtedly, there is great potential to expand and improve African Market Gardens as a part of market-driven agriculture in sub-Saharan Africa. For the system to be sustainable, the fertility status of soils needs to be raised; and better natural resource management needs to be integrated with improved and adapted genetic resources. Moreover, combining crops, livestock and trees further helps farmers to manage risks and generate higher incomes. Equally crucial are policies that lead to functioning market channels which make agriculture more profitable, as are innovations that improve farmer integration into markets.

### *Fertilizer Microdosing in Sub-Saharan Africa*

For sustainable soil fertility management in sub-Saharan Africa where farmers cannot think of buying and applying appropriate rates of fertilizers, ICRISAT, CIAT and IFPRI and their partners are encouraging farmers to apply a small quantity of the most essential fertilizer directly to the plant at the right time. Termed "microdosing", this method is helping thousands of farmers in Western and Southern Africa to get their crops to mature faster and overcome the worst effects of drought.

Participatory on-farm trials conducted during three seasons in the SAT region of Zimbabwe to assess the benefits of small rates of manure (3-6 t $ha^{-1}$) and nitrogen fertilizer (8.5 kg N $ha^{-1}$), showed that maize yields increased substantially due to the application of manure and nitrogen fertilizer. The increase in yield was strongly related to rainfall received across seasons. The results demonstrated that there is potential to improve livelihoods of smallholder farmers through the use of small rates of manure and N under semi-arid conditions (Ncube *et al.*, 2006).

### *Rice-Wheat Systems in Asia*

In Asia, the implementation of reduced or zero tillage technologies by the Rice-Wheat Consortium consisting of CIMMYT, International

Rice Research Institute (IRRI), ICRISAT, International Potato Centre (CIP) and International Water Management Institute (IWMI), and national partners from India, Nepal, Pakistan and Bangladesh are transforming the rice-wheat fields in the Indo-Gangetic Plain (IGP). It is estimated that these technologies have been adopted on over 3 million ha out of a total 13.5 million ha under rice-wheat systems in the IGP. As a result, wheat yields have increased by 0.25 t $ha^{-1}$ on an average. The improvement in yield has been due to reduced soil moisture loss and improved organic matter and soil health; and the implementation of water-wise practices that have helped save 1.5 to 3 billion $m^3$ water from the soil profile.

### *Integrated crop-livestock system for stabilizing sloping lands, Guizhou, China*

In the Guizhou province of China, population pressure has led to rapid deforestation and the cultivation of fragile and unstable sloping lands. These lands are fast degrading and are unable to meet the food and fodder requirements of humans and livestock. In Lucheba watershed in Guizhou province, alley cropping of forage crops (such as wild buck wheat) with fruit trees (such as peach or pear) as hedgerows has been effective in controlling soil erosion and increasing farmers' income from these lands. The fruit trees provide high income, while growing of buckwheat provides nutritious fodder for livestock; and the agroforestry system protects soils from erosion. Farmers in the watershed area are happy, as *in-situ* forage production economises labor, saving them the trouble of collecting fodder from the forest. Additional measures such as contour cultivation, planting of *Gliricidia* plants and the cultivation of improved forage species (ryegrass, alfalfa and *Cichorium intybus)* is helping stabilize the sloping lands. Indeed, Lucheba watershed has transformed the economy of its populace through the integrated crop-livestock system, increasing per capita income from $ 200 to $ 325 in just two years!

## *Watersheds in the SAT*

### *An integrated watershed management model*

ICRISAT is leading the challenge to address uncertainties in agricultural production affecting 560 million poor in the SAT. Parched lands, extremely degraded natural resources with unabated population pressure characterize the SAT in the developing world.

Based on 25 years of learning from strategic and on-farm development research, the ICRISAT-led watershed consortium has developed an innovative participatory approach to managing watersheds. The consortium approach revolves around four Es (empowerment, equity, efficiency and environment), which are addressed by adopting specific strategies prescribed by four Cs (consortium, convergence, cooperation and capacity building). It brings together institutions from the scientific, non-government and farmers groups for knowledge management convergence. Collective action among all stakeholders plays a major role.

The consortium-led watershed management model is based on a farmer-participatory approach, the use of new science tools, on-station to on-farm knowledge flows, a holistic systems approach with an integrated genetic and natural resource management (IGNRM) strategy providing site-specific solutions, a consortium of institutions for technical backstopping, continuous monitoring and evaluation by stakeholders, community and women empowerment, and environmental protection. The consortium strategy has facilitated the exchange of knowledge and technologies among partners. The implementation of integrated watershed management practices at several locations in Asia, including extensive studies in SAT India, has resulted in reduced land degradation and improved rural livelihoods through increased incomes (Wani *et al.*, 2003).

***Meta-analysis of case studies on watershed programs in India***

In an analysis and synthesis of past research on watersheds, Joshi *et al.* (2005) has assessed the performance of watershed programs in India by employing a meta-analysis. The study, based on an exhaustive review of 311 case studies on India's watershed program, aimed at documenting efficiency, equity and sustainable benefits accruing from the case studies. The following lessons were drawn from the study:

- The analysis showed that the mean benefit-cost ratio of a watershed program in the country was quite modest at 1:2.14.
- The internal rate of return was 22 %, which is quite comparable with many rural development programs implemented in the country.
- The watershed programs generated enormous employment opportunities, augmented irrigated area, increased cropping intensity and conserved soil and water resources.

- Watershed programs were shown to perform best in areas that targeted low and medium income groups, which were jointly implemented by the state and central government, and where there was effective people participation, and an annual rainfall ranging between 700 mm and 1100 mm.

The watershed program is silently rejuvenating and revolutionizing rainfed areas in the country. It was suggested that different rainwater management technologies are needed for the dry (500-700 mm) and wet (>1100 mm) regions of the country. It was also noted that a lack of appropriate institutional support is impeding the tapping of potential benefits associated with the programs.

*Impact of a watershed case study in eastern Rajasthan (India)*

An integrated watershed program was implemented in Bundi district of Rajasthan through a TATA-ICRISAT-BAIF project in 2002-2006. It led to increased water availability that stabilized wheat productivity at increased yield level; augmented the area under cultivation, increased cropping intensity and led to diversification with additional production of vegetables in summer in the tank bed area. The program in Bundi also provided employment opportunities to local people. Improved water availability in the watershed not only increased the area under double cropping but also led to increased productivity largely due to the adoption of integrated soil, water, nutrient and pest management options. Enhanced cropping intensity and diversification generated extra off-season activities in the village, resulting in substantial reduction in migration in search of employment. Crop diversification with short-duration pigeonpea, safflower and chickpea helped farmers move away from high water requiring crops such as wheat. As these soils were found severely deficient in zinc, boron and sulfur, the application of these nutrients increased crop yields by 32 to 70 %.

During the study, 45 hectares of degraded community lands were reclaimed by planting the land to silvipastoral system, which integrates multipurpose trees, shrubs, legumes and grasses. Rehabilitating degraded lands increased biodiversity and total number of species. Production of forage in degraded common property resources enabled villagers to increase their livestock-based activities, resulting in extra cash income. This goes to prove the resilience to the system, especially during drought years.

*Watershed case study in the Guna district of Madhya Pradesh (India)*

In the Indian SAT, implementation of the watershed plus activities through the Sir Dorabjee Tata Trust Project during the last 5 years in Madhusudhan Garh in Guna district of Madhya Pradesh, has radically transformed the lives of the tribal Banjara (nomad) community. With improved water availability in farmers' fields, the women folk not only grow enough vegetables to meet their household needs, but in some cases make a small income selling them in the local market. The implementation of harvest plus activities by ICRISAT and an NGO, BAIF, through this project has helped farmers to make better use of natural resource management practices. Farmers have diversified systems by raising nurseries and producing vermicompost, and the system's productivity has been stabilized by farmers' adoption of integrated nutrient management and integrated pest management practices.

*Macro benefits from Boron, Zinc and Sulfur in the Indian SAT*

The ICRISAT-led on-farm community watershed research in selected districts of Andhra Pradesh, Madhya Pradesh and Rajasthan revealed that the prevailing subsistence agricultural systems have depleted the soils not only in macronutrients, but also in micronutrients such as boron and zinc, and secondary nutrients such as sulfur. For example, widespread deficiencies (80-100 %) of boron, zinc and sulfur were observed in farmers' fields in Andhra Pradesh.

Substantial increase in yields (20 to 80 %) due to sulfur, boron and zinc amendments, and a further increase by 70 to 120 % due to sulfur, zinc, boron and adequate nitrogen and phosphorus amendments were observed in farmers' fields.

The implementation of soil and water conservation practices along with nutrients increased crop yields, raised incomes and more importantly, increased rainfall use efficiency (kg grain yield $mm^{-1}$ of rainfall) (Rego *et al.*, 2005).

## *Breeding Crop Cultivars for Drought Tolerance*

Drought is globally the most important constraint to crop productivity. ICRISAT focuses on identifying molecular markers for the quantitative trait loci (QTLs) controlling traits contributing to drought tolerance/

avoidance in pearl millet, sorghum, chickpea and groundnut and on the marker-assisted introgression of these QTLs into adapted cultivars/farmer parental varieties and elite breeding lines. In pearl millet, we have pursued QTLs associated with maintenance of grain yield under terminal drought conditions.

## Conclusions

To sum up, the Oasis program will bring about science-led development in a coordinated manner to arrest desertification and stabilize drylands in the SAT and dry regions of the developing world. Most importantly, collective action by community members would enhance the system's sustainability. The empowerment of community-based organizations has enabled farmers to act as trainers for their peer groups. In this endeavor, information communication technology (ICT) will play a crucial role to create awareness about new technologies and facilitate their implementation. Such a holistic integrated approach at the landscape scale will not only minimize land degradation and increase water conservation but also increase incomes on a sustainable basis.

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