DRYLANDS

Sustaining Livelihoods and Conserving Ecosystem Services

SUMAMAD

By Richard Thomas, Naomi Stewart & Thomas Schaaf

A POLICY BRIEF BASED ON THE SUSTAINABLE MANAGEMENT OF MARGINAL DRYLANDS (SUMAMAD) PROJECT

United Nations Educational, Scientific and Cultural Organization
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Contents

Foreword

The drylands of the world occur on every continent, covering some 41% of the terrestrial surface. One third of humanity inhabits these harsh degrading landscapes, eking out a living through adaptive processes that have served them well until recent increases of land degradation. Growing pressures from population growth, increasingly erratic climatic conditions, and a general lack of investment in drylands are now putting extraordinary strains on the livelihoods of dryland inhabitants and the integrity of their ecosystems. Desperation is resulting in migrations from drylands, threatening not only the political stability of these countries, but also that of neighbouring countries and even other continents.

Drylands are prevalent in poor developing countries and have been marginalized and left outside of mainstream development efforts which focus on relatively better-off environments. Nowadays it is recognized that the alleviation of poverty and the achievement of development goals cannot be achieved without significant attention to drylands.

Far from being of little value, dryland ecosystems are rich sources of flora and fauna biodiversity that are already adapted to harsh environments. Preservation of this biodiversity will be essential for confronting the risks of unpredictable weather patterns that are expected to bring increasing droughts and floods.

Ensuring dryland inhabitants have viable livelihoods will be key to their survival. Achieving this unquestionably involves the prevention and/or reversal of ecosystem degradation. Relieving pressure on the natural resource base by offering alternative livelihood options that do not exert excessive pressure on land is a key strategy pursued in the Sustainable Management of Marginal Drylands (SUMAMAD) project. This project began with a first phase running from 2003-2007, and a second phase from 2009 until 2013. The second phase of the project built on the successes of the first phase and focused on:

Han Qunli
Director, UNESCO Division of Ecological and Earth Sciences
Secretary, Man and the Biosphere (MAB) Programme

- The improvement of dryland agriculture and the rehabilitation of degraded lands;
- The promotion of sustainable livelihoods, and;
- The development of policy-relevant guidelines for future land use.

Using multi-partner research teams in nine countries spanning Africa, the Arab States, Asia and Latin America, the SUMAMAD project has achieved remarkable impact in the participating countries with multi-million dollar investments planned from national sources that incorporate many of the project's outputs.

The foresight of the main donor, the Flemish Government of Belgium, is recognized and acknowledged by the project's participants. It is an example of how relatively small amounts of funding per country can leverage larger efforts capable of having national impact.

I take this opportunity to thank participants in the SUMAMAD project from the national teams and the

Photo Credit: UNESCO

excellent collegial spirit demonstrated through their willingness to exchange ideas, information and advice. The United Nations University's Institute for Water, Environment and Health (UNU-INWEH) and the Man and the Biosphere (MAB) Programme of the United Nations Educational, Scientific and Cultural Organization (UNESCO) have collaborated efficiently over the 10 years of the project, a partnership made possible by the generous funding provided by the Flemish Government of Belgium.

The project relied on the willingness to share experiences and expertise amongst the national teams that included the Universidad Mayor de San Andres (Bolivia), le Centre Nationale pour la Recherche Scientifique et Technologique (Burkina Faso), the Chinese Academy of Sciences (China), the University of Alexandria (Egypt), the Central Arid Zone Research Institute (India), the Fars Research Center for Agricultural and Natural Resources (Islamic Republic of Iran), the Royal Society for the Conservation of Nature (Jordan), the Council of Research in Water Resources (Pakistan) and the Institut des Régiones Arides (Tunisia).

A potentially high impact network has been established through the SUMAMAD project and we wish them continued success in their efforts to combat land degradation through improved livelihoods and human well-being. The approach taken in the project will be a model example of how to merge scientific knowledge with local knowledge and how to ensure that research findings will lead to widespread impact.

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Summary for Decision-Makers

Successful interventions for degraded drylands require holistic approaches that focus on improved income generation from agriculture and alternative livelihood sources. The achievement of global development goals cannot be realized unless attention is given to drylands that house many of the world's poor. It is therefore no longer a question of *if* there should be investments in drylands, but rather how they can be best used to alleviate poverty and halt degradation of natural resources. As demonstrated by the SUMAMAD project, an understanding of how land managers make land use decisions needs to be comprehensive and consider all sources of income that dryland inhabitants obtain from a multitude of agricultural and non-agricultural activities.

Forward looking policies that deliver a portfolio of options encouraging investment in drylands are needed. These include economic, communication, educational, and complementary regulatory instruments, and incentives for all stakeholders to apply sustainable land management practices.

Novel, interactive information and knowledge platforms are required to bring stakeholders together to develop shared understandings, visions, and action plans. Stakeholders include policy advisors, policy decision makers, local communities, researchers, and others. Much more is needed to improve communication between science and policy. National seminars organized by the SUMAMAD project proved to be a successful option.

Future research for development projects will focus more on engaging all stakeholders and determining which knowledge, attitudes, and skills need to develop and change. Land users need better access to information on options, and scientists need to understand the policy making processes that can help stakeholders identify barriers to achieve widespread impact of research findings. The SUMAMAD project worked on this issue with favourable success.

Interactions, discussions, and deliberations between researchers and policy makers in national seminars help disseminate research findings beyond the narrow audiences of peer-reviewed journals. Scientists are rewarded by obtaining degrees and peer-reviewed publications. The SUMAMAD project encouraged various forms of other communications, ranging from meetings and discussion groups to the production of new crop calendars based on climate analyses and land use scenarios, and public awareness-raising over new alternative livelihood options, such as chicken farming and fisheries. A range of publications and annual national seminars from the research teams enabled the engagement of farming communities, NGO's, and local and national governments. This also raised much needed public awareness of environmental and human well-being issues.

Strengthening the exchange of knowledge, demands, and needs between scientists and policy makers improves the science-policy interface and ultimately the adoption and adaptation of promising options. Efforts to engage the full spectrum of stakeholders demonstrably facilitated the up-scaling of interventions achieved through modest financial investments in research. By facilitating stakeholder discussions and exchanges through training events and annual national seminars, research findings and recommendations of the SUMAMAD project achieved national and international impact in several participating countries. Researchers also catalyzed the formation of 'boundary organizations' that helped strengthen linkages between scientific knowledge and the policy process.

Photo Credit: UNESCO

Why Invest in Drylands?

Increasing investments in drylands is financially and socially rewarding. Drylands are perceived as desolate ecosystems with low production potential, subject to desertification or land degradation, and as 'investment deserts' plagued by chronic under-investment from governments and the private sector. The reality is quite different; recent economic assessments reveal that highly productive non-dryland areas have only marginal rates of economic returns on investments, whereas rates of 12- 40% have been reported in drylands[1,2]. The potential of these economic returns has finally spurned interest from the private sector, which is now focusing on small holder farmers, including those in drylands[3].

Businesses are essential to dryland development. By integrating small scale producers into their supply chains and providing marketing, access to inputs, and technical skills, the private sector has a key role to play in dryland rehabilitation and sustainability. The recent change in attitude of businesses towards sustainable development practices provides a timely opportunity to expand and increase viable public-private partnerships.

Policy makers facilitate investment by focusing on incentives to adopt sustainable land management practices and encouraging alternative livelihoods. Payments for ecosystem services, subsidies, and facilitating micro-finance schemes are among the options that policy makers can offer to complement and reward investments in drylands.

Securing the livelihoods of dryland inhabitants is an urgent global challenge. Harsh living conditions are likely to worsen with increasing populations and the exacerbating effects of climate change, which is expected to result in hotter, drier weather with more erratic rainfalls. Achieving the Millennium Development Goals and their likely successors, the Sustainable Development Goals, cannot be done without considering drylands and their inhabitants as a priority, given their extent and importance (covering 41% of the earth's land surface and being home to one third of the human population[4]). Ninety percent of dryland populations are found in developing countries where poverty persists and affects the most vulnerable: women and children. Population growth rates also remain highest in dryland countries, increasing the pressure on the environment to supply food, shelter, energy, and water. A lack of job opportunities and resulting desperation are driving forces behind migration from dryland countries as well as the internal displacement of people from rural to urban areas. For example, as many as 60 million people may migrate from Sub-Saharan Africa to North Africa and Europe by 2020.

Drylands provide important yet under-appreciated ecosystem services[1] that will be of utmost importance in future climate change mitigation and global food, water and energy security. This includes primary production of food, fibre, medicinal and pharmaceutical plants, timber, biofuels, and solar energy. They act as regulators of water quantity and quality, with significant aquifer storage capacity that could sustain small rural populations when combined with carefully managed aquifer recharge – Africa already has several examples of this[4,5]. Carbon storage in dryland soils accounts for as much as one third of the global stock, even with relatively low amounts per unit area when compared with tropical forests[1]. Many of the world's staple crops originate from drylands making them a vital source of biodiversity for our food production[6]. With many regions predicted to become hotter and drier, drylands are also a major source of genetic pools that can confer adaptions to the more extreme conditions anticipated. For all these reasons and more, investment in their preservation is therefore of critical urgency.

Drylands are not isolated and interact with other ecosystems through trade and substantial seasonal migration of people into urban areas. Drylands offer the potential for renewable energy generation through abundant solar and wind resources, backstopping the burgeoning energy requirements of more densely

Photo Credit: UNESCO

populated peri-urban and urban areas. Their remoteness offers opportunities for eco-tourism, where wilderness is valued at a premium. Aggregating the value of these services demonstrates that drylands contribute significantly to national gross domestic product (GDP), and the loss of these services is estimated to cost developing countries 4-8% of their GDP. This is a substantial loss in addition to the human tragedies seen daily in the media that result from droughts, forced migrations, political instability, and conflicts over land/water resources and related wars.

Box 1. The SUMAMAD project

This policy brief focuses on the second phase of the Sustainable Management of Marginal Drylands (SUMAMAD) project that ran from 2009-2013. The project was a joint initiative of United Nations University - Institute for Water, Environment and Health (UNU-INWEH) and the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Division of Ecological and Earth Sciences with its Man and the Biosphere Programme, and was primarily funded by the Flemish Government of Belgium. The geographic span of the project ranged from dryland sites in Bolivia (Latin America), Burkina Faso (Western Africa), Egypt, Jordan, and Tunisia (Arab States), and China, India, Iran, and Pakistan in (Asia). The overall goal of the project was to contribute to vibrant rural dryland communities with sustainable and diversified livelihoods while conserving the natural resources. The three primary objectives of the project were:

- Fostering scientific drylands research through the improvement of agriculture, sustainable use of natural resources, and regeneration of degraded drylands;
- Promotion of sustainable livelihoods in drylands through the exploration of alternative income-generating activities, and;
- Preparation of policy-relevant guidelines for decision makers in drylands including scenarios for land use change and improved interfacing of science and policy.

A cross-cutting objective was strengthening capacity within target areas and countries through training and environmental research exchanges.

Even though the sites varied in terms of geography, environment, social, economic, and political circumstances, a common methodological approach was used to monitor results and promote an active exchange of ideas amongst the sites and project teams. Participatory approaches facilitated detailed socio-economic surveys that elicited the problems and indigenous knowledge of each site and allowed joint design, planning, and testing of promising options.

In addition to a focus on improving existing production systems through multiple stakeholder participatory action research, the project continued its theme from the first phase of identifying and promoting a diversification of livelihoods in order to ensure food, energy, and water security, and health and economic well-being.

Annual national seminars were a key strategy to bring different stakeholders together to discuss their multiple objectives and perspectives. These events served as 'boundary work' that helped the scientific teams interface the application of scientific knowledge with policy making. Each team was asked to produce policy-relevant guidelines from their work in addition to the normal scientific theses and publications.

CHAPTER 2

Integrating Sustainable Land Management with Livelihoods

The fundamental challenge for drylands is enhancing the adaptive potential and resilience of dryland communities. Dryland populations have survived harsh socio-ecological environment for centuries through adaptive processes that integrate land management with livelihoods. These adaptive processes are generally under-appreciated[7]. As pressures on the environment grows through population increase and better living standards, new scientific information and knowledge needs to be merged with local knowledge.

Many technical solutions to the problems of drylands have failed, as appropriate solutions must include social, political, economic, and cultural aspects. Current approaches to better land management focus on ecosystem services[1] that enhance livelihoods and human well-being while protecting the natural resource base from degradation. The dilemma lies in determining how to beneficially use ecosystem services without repeating their historical degradation. This degradation has been occurring since hunter gathering was replaced by sedentary agriculture and, while land frontiers were open, it was convenient to move into new areas when exploited land was exhausted. Today this option is closing with little new suitable land available for agriculture or other land uses. This limited land availability creates the challenge of focusing on intensifying production from land already in use, while ensuring ecosystem functioning and integrity. An additional aspect to consider is land acquisitions by wealthier sectors of the population, which drives the poor onto even more marginal lands that are often unsuitable for sustainable production systems.

Realizing the potentials and opportunities in drylands requires a change in mind set that emphasizes: reasons for market failures; provision of incentives that help lower investment costs; establishment of equitable land policies including tenure issues, and; introducing and improving existing alternative livelihoods that bring wealth and dignity, alleviate desperation, and very importantly - focus on gender inequalities. There is also a need to specifically create job opportunities for youth who are disenchanted and desperate in many dryland countries. Neglect of the youth demographic is likely to result in increasing tensions and possibly civil unrest. Recent evidence shows that the growing youth populations which are occurring in many dryland countries results in many unemployed males. When combined with these other factors this may be an indicator for political violence[8].

Dryland inhabitants that rely on natural resources for their livelihoods are generally those that are 'left behind" contributing to the 'forgotten billion'[9]. It is imperative to have viable livelihood options for this billion, who represent some of the poorest people on the planet. As a result, there is a need to improve the production of rangelands, and rain-fed and irrigated agricultural systems for food security using technical interventions. However, such improvements must occur without further land expansion and/or detrimental effects on the environment. A range of agricultural options currently exist that can improve forestry, crop, and rangeland livestock production systems. This includes: the judicious use of fertilizers now available in small amounts for micro-dosing, organic fertilizers, more efficient irrigation and water harvesting, soil conservation and germplasm that is better adapted to droughts, shorter growing seasons, pests, and diseases[10].

This pathway of options is represented by the left hand side of Figure 1, which shows pathways to achieve sustainable land management and livelihoods in drylands. Some of these options were explored in the SUMAMAD project.

1) Ecosystem services are the benefits derived from the natural resources. They are categorized as: *provisioning services* such as food, fibre, wood, and water; *supporting services* necessary for the production of other services such as soil formation or nutrient cycling; *regulating services* such as water purification, erosion control and pollination, and; *cultural services* that are non-material such as recreation and spiritual uses[4].

Photo Credit: UNESCO

Box 2. Adding value to existing production systems

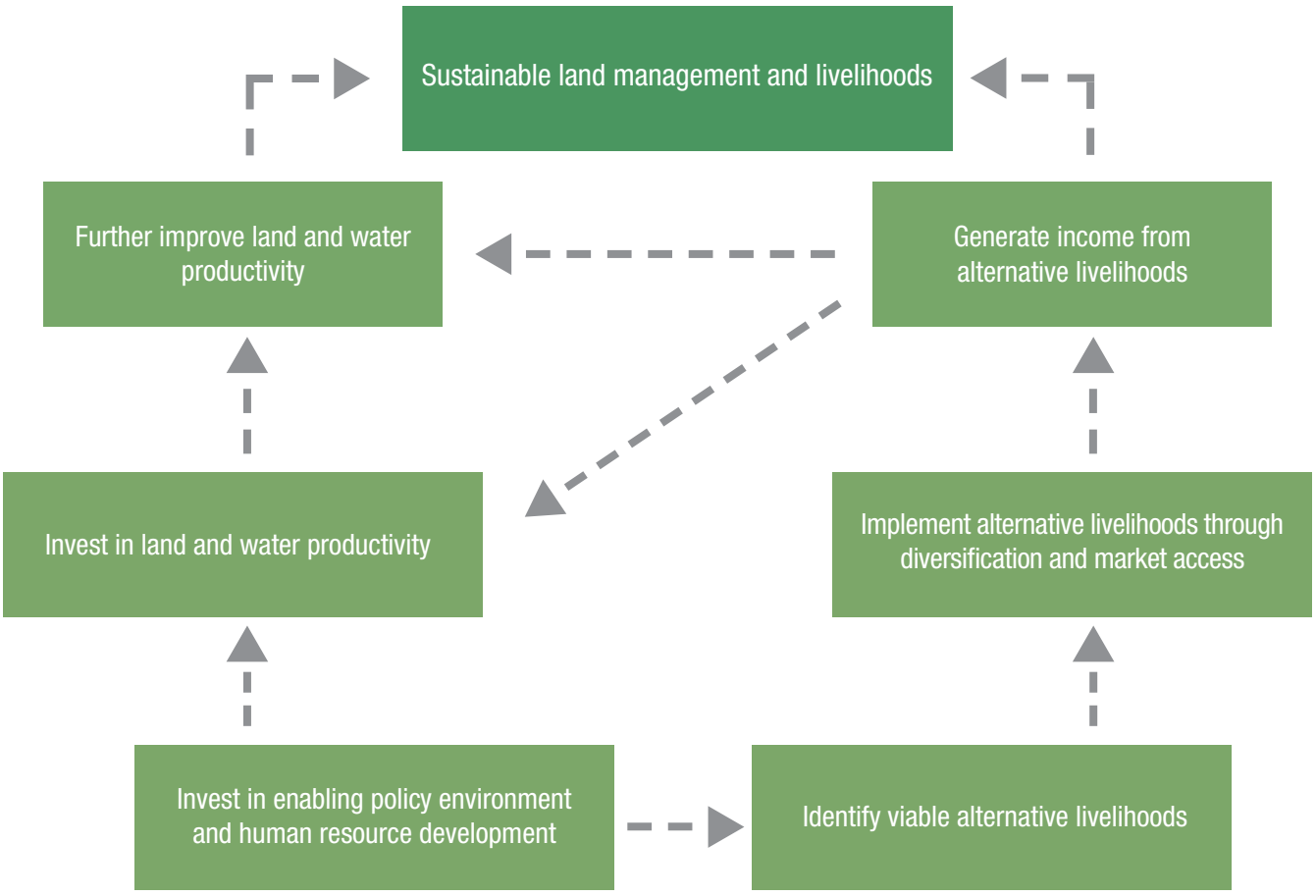
In Burkina Faso, crop diversification has helped to raise incomes through the sales of micro-irrigated and organically manured vegetable crops such as onions.

In India, improved varieties of crops such as wheat, Indian mustard, cumin, etc., have resulted in yield increases of up to 30%.

In Bolivia, organic manures and deficit irrigation is improving the production of Bolivia's important income generating quinoa crops in the Altiplano. This was complemented by an analysis of climate variability in order to improve the water efficiency of deficit irrigation via a 'quinoa calendar', the zoning of quinoa production in the Altiplano, and the potential economic effects of increased variability on quinoa production.

Photo Credit: Harriet Bigas

Figure 1. Pathways for attaining sustainable land management and livelihoods in drylands through consideration of agricultural and alternative livelihoods[14,15].



The majority of dryland inhabitants rely on agriculture for 50% or less for their household income. To cope they engage in alternative livelihoods that are not directly dependent on the natural resource base, represented in the right-hand pathway of Figure 1. Alternative livelihoods can be developed *in situ*, such as the expansion of artisanal goods, eco-tourism, high value organic agricultural products, renewable energy generation, and apiculture and aquaculture using recycled wastewater. Value can also be added to existing plant and animal products by processing and direct marketing which gives greater returns to the producers. Livelihoods can also be generated *ex situ*. Migrants may chose this option by taking human and financial capital out of rural areas, but then sending back remittances that can be used to improve dryland ecosystems. This is represented by the diagonal arrow in Figure 1.

Both of the pathways in Figure 1 require better enabling environments that include incentives or subsidy schemes, taxes, implementation of bans, establishment of new markets, etc[2]. The SUMAMAD project delivered important results in both pathways, in terms of tangible outputs and process development (see Boxes 2, 3, and 4).

Box 3. Rehabilitating degraded drylands through SUMAMAD

In India's Rajasthan State, a Village Community Pasture Development Committee was formed in the Jaisalmer region in order to decrease the pressure on rangelands through deferment of grazing. When compared with unprotected areas, this reduced soil erosion losses by 3-5 fold.

In Iran, funding of $250,000 from the government facilitated the additional establishment of around 300 ha of flood water spreading systems, bringing the total rehabilitated area to over 900 ha. The systems capture water that would otherwise be lost through evaporation, which it is then used for increased biomass production and groundwater recharge, ultimately regenerating the degraded plains.

In Pakistan, an area of the Cholistan desert near the Lal Sohanra Biosphere Reserve has been rehabilitated using a rotational grazing system and the application of supplementary irrigation. This has resulted in a 700% increase in carrying capacity.

In Egypt, scenarios were developed for the management of zones of the Omayed Biosphere Reserve to determine likely impacts resulting from the changing land uses that occur with urbanization, climate changes, and the introduction of irrigation waters from the Nile. Options examined included tree planting, propagation of legumes and grasses, vegetation protection from grazing, and conservation agriculture. These options were aimed at protecting and rehabilitating parts of the biosphere reserve while allowing continued exploitation of other zones for urbanization and intensive agriculture. Such scenario building was used to inform decision makers on appropriate land and (especially) water management systems needed in the rapidly changing northern coastline of Egypt.

Box 4. Alternative livelihoods studies by the SUMAMAD partners

In Burkina Faso, fruit-bearing trees and medicinal plants that included mangoes, acajou, nere, tamariner, baobab, and kartie, were established in new agroforestry systems to help relieve pressure on the environment resulting from unsustainable cotton production. Women particularly benefited from these interventions by processing the fruits and leaves for local market sales. Similarly, in India, multipurpose fodder trees and medicinal shrubs including *Acacia senegal*, *Colophospermum mopane*, *Salvadora oleoides*, and *Commiphora wightii* were raised in nurseries and distributed to farmers to increase crop diversity and generate income.

In China, the introduction of free range chicken farming to relieve pressure on grasslands raised family income 6-fold through sales of chickens, eggs, and hay from 'spared' biomass. This alternative production system is being considered for widespread adoption in other degraded grasslands via the establishment of "eco-husbandry" demonstration regions as part of a 30 billion CYN (US$ 4.95 billion) investment by the Chinese government. Over 400,000 chickens have been distributed across 10 banners (regions) in Xilingol, spurning a chicken rearing industry. This innovation provides an alternative to China's efforts to control wind erosion via tree planting, since chickens have less devastating impacts on soils than ruminants. Raising free-range chickens increased income by 54% when compared with sheep grazing. Additional benefits also accrue from farmers being able to sell hay that would normally be grazed, and from greater biomass and ground cover, which reduces soil erosion.

In Tunisia, local NGO's and farmers tested an alternative income generation activity based on the exploitation of medicinal and aromatic plants, especially dried mint used for teas. Profit margins increased by 200-800% for poor families, and especially helped 52 rural women. Training in plant production, market standards, and the impact of quality on sale price and producer returns has helped stimulate interest in this alternative pathway, and enhance livelihoods in the governorates of Tataouine and Medenine.

Failed top-down technological approaches have given way to more inclusive approaches to rural development and power sharing in drylands and other ecosystems[11,12]. At all levels from local to national and international, the participation of all relevant stakeholders is considered essential for the adoption and adaptation of new interventions, equitable distribution of lands and the design of policies, regulations and incentives that have realistic potentials for implementation. This requires collaboration amongst social, political and business leaders to create new partnerships that include public-private endeavours.

Managing the complexities of sustainable livelihoods for dryland inhabitants while conserving natural resources, will require new partnerships with stakeholders of varying expertise. These will include public, private, civil, and academic institutions and organizations that coalesce at the local, national, and international levels in a widening of the scope of partnerships. This diversity will improve planning and result in increased adoption of new approaches, technologies, policies, etc. Partners in the SUMAMAD project identified areas where such new arrangements are necessary (see Table 1). The up-scaling of the findings of the SUMAMAD project has begun at some sites (Bolivia, China, Egypt, India, Iran, and Pakistan) and continued up-scaling will require identification of who or which organization can take on these responsibilities.

Photo Credit: Richard Thomas

Box 5. Strengthening institutions

In Burkina Faso, university staff, the Centre National de la Recherche Scientifique et Technologique (CNRST), the commissioner of the biosphere reserve, local producers, and an inter-village NGO association for natural resources and wildlife management (AGEREF) combined forces and worked together to plan for better conservation and development of the villages surrounding the Mare aux Hippopotames Biosphere Reserve (MHBR).

In Iran's Gareh Bygone Plain, four cooperatives were established with the help of the Research Society for Sustainable Rehabilitation of Drylands (REaSSURED), an NGO. These groups participated in the construction of flood water spreading systems, and over 110 households are now benefiting from managing the aquifer for productive purposes. Additionally, the groups prioritized problems in the area and identified barriers to further progress. Government authorities are engaged and providing additional financial support – an essential synergism.

In the Dana Biosphere Reserve in Jordan, the SUMAMAD project brought together government officials, key individuals from the communities, and livestock owners to discuss the development of a community action plan to avoid overgrazing while ensuring viable animal production systems. This resulted in the establishment of a cooperative for livestock owners in the Al Barrah grazing area.

To help control overgrazing of rangelands in the Cholistan desert of Pakistan, the SUMAMAD project brought together the Cholistan Development Authority, the Pakistan Council of Research in Water Resources, the Cholistan Institute of Desert Studies, the Forestry department of the provincial government of Punjab, and members of the local community to prepare guidelines for grazing and to prepare a major project for up-scaling the work in the Punjab.

Many of these developments were stimulated by the annual national seminars arranged by each of the SUMAMAD country teams. Different stakeholders were involved in each case, but the identification of common problems and progress towards the development of agreed action plans by the relevant stakeholders was key to ensuring the sustainability of the interventions.

From Research to Impact

The widespread adoption of interventions rarely occurs without attention being paid to the impact pathways and the barriers. Only by identifying pathways and overcoming barriers can accomplishing sustainable land management and livelihoods be scaled out and sped up. It is often necessary to first understand the contextual nature of successful interventions. Economic growth can no longer be de-coupled from environmental degradation and instead must be tightly linked to societal well-being and sustainable development.

To achieve impact, attention must be paid to the governance, policy, financial, technological, and management changes that create an enabling environment for improvements. As with all research for development projects it is a challenge to convert research outputs into development outcomes. The SUMAMAD project illustrates some of the barriers to impact and how they can be overcome (see Table 1 and Box 5). The 'theory of change' was applied to the case studies, to describe how the project worked by focusing on the expected impact pathways (see Box 6). Targeting the research-to-development continuum includes the connections (or lack thereof) amongst relevant organizations that affect the conversion of research outputs into development outcomes.

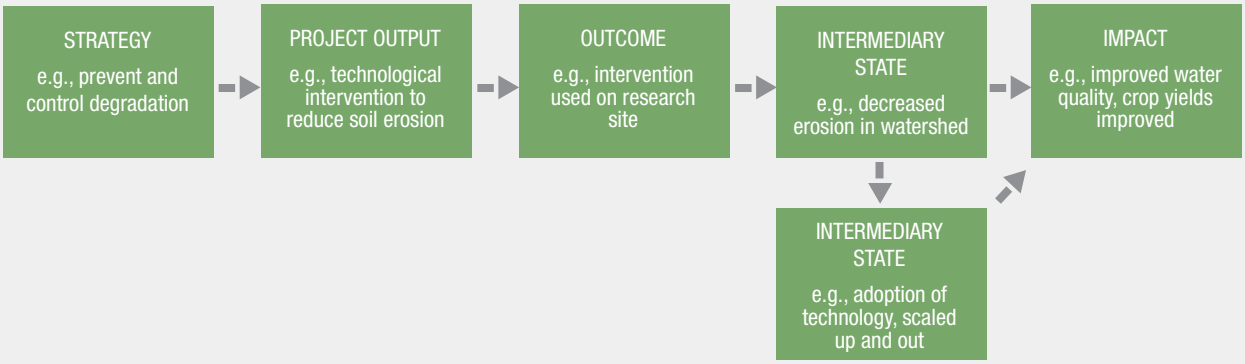
Photo Credit: UNESCO

Photo Credit: UNESCO

Table 1. Impacts of SUMAMAD Research		
Research site/country	Major impacts achieved	Where change is needed for greater impact
Altiplano, Bolivia	Crop calendar, rotations, irrigation, and fertilizer recommendations for quinoa revised	• Better market chains for quinoa
Mare aux Hippopotames Biosphere Reserve, Burkina Faso	.Ecological orchards using agroforestry introduced. Fishing, apiculture, mushrooms, and tourism identified as alternative livelihoods, especially for women	• Environmental education, policies to promote sustainable land use, particularly in cotton fields
Hunshandake Sandland, China	Chicken farming as an alternative livelihood option to reduce pressure on grasslands. State Council investing in up and out scaling interventions to regenerate grasslands via eco-husbandry demonstrations.	• Strengthened market chains for organic foods (milk, eggs, beef, mutton, and chicken)
Omayed Biosphere Reserve, Egypt	Increased awareness of loss of ecosystem services, especially water resources. Small scale solar-powered desalinization plants and alternative income generation for women.	• Greater access to land and technological information, particularly for women
Western Rajasthan, India	Introduction of better adapted crop and fodder varieties. Rehabilitation, groundwater conservation, wind erosion control and afforestation strategies demonstrated.	• Cooperative production groups and strengthened marketing information
Gareh Bygone Plain, Iran	Over 600 ha flood water spreading established for groundwater recharge. Honey and jojoba production as alternative income generators. Four cooperatives established for natural resource management.	• Training in market practices and water management
Dana Biosphere Reserve, Jordan	Community-based grazing management established with guidelines for extrapolation.	• Up-scaling of guidelines with enabling policies
Lal Sohanra Biosphere Reserve and Cholistan Desert, Pakistan	Grazing capacity of rangelands increased by up to 700%. Cholistan Development Authority adopts findings for out-scaling.	• Market infrastructure
Zeuss-Khoutine watershed, Tunisia	Dynamics of *Acacia* planting determined. Groundwater recharge structures monitored. Value added to mint production with 200-800% increase in profit margins.	• Better awareness of integrated natural resource management needed by stakeholders. Market chains require improvements.

Box 6: From research to impact - applying a 'theory of change' (TOC) approach

TOC is a method used to describe how a project is expected to work and specifies the project's strategy, output, outcomes or intermediary states, and impact (*www.theoryofchange.org/toco-software*). It identifies external assumptions, impact drivers, and pathways to impact, usually via a flow chart as represented below in a hypothetical example. TOC helps create partnerships that are not presented in logical frameworks. It starts with a definition of an ultimate goal that is then broken down into a causal pathway with intermediate outcomes or pre-conditions, indicators, and assumptions for each step along the pathway.



TOC uses logic models or impact pathways as frameworks that help link together the project's activities with expected outputs and outcomes. Key assumptions include internal and external factors that may promote or constrain progress[13]. Importantly, the process helps determine why and how an intervention is or is not affecting change. Analyses include identifying the changes in practice required to achieve the project's objectives, and the changes in knowledge, attitudes, and skills needed to bring about these changes in practices. These are discussed amongst participants during the project life cycle via iterative learning cycles as indicated below.

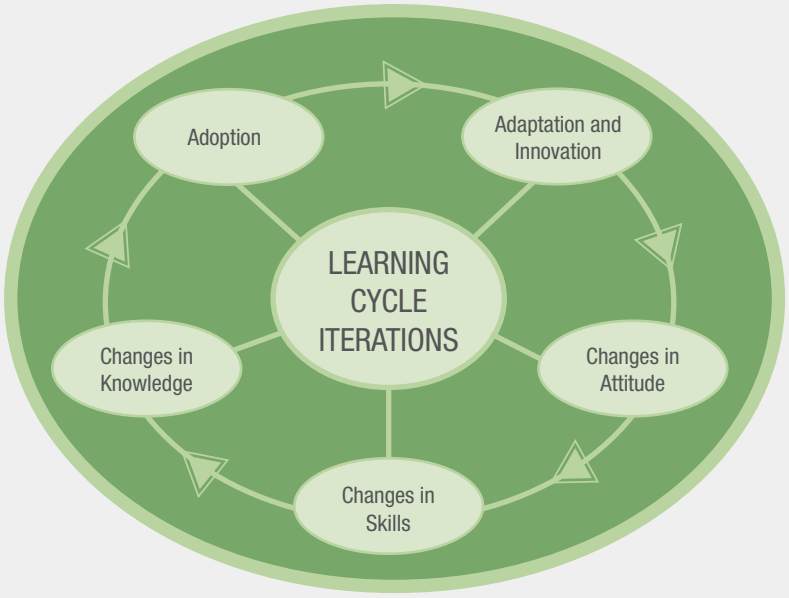


Photo Credit: UNESCO

Moving Ahead in Drylands

SUMAMAD results demonstrate how to increase production and income by: improving existing agricultural systems, adding value to products, and introducing novel income generating opportunities. These actions offer hope that populations can continue to live in harsh environments with better prospects and improved human well-being while also conserving the natural resource base.

Multi-stakeholder partnerships are essential to sustainable dryland management. The new institutional and collaborative partnerships undertaken by the project have brought waves of enthusiasm back to desperate populations that struggle to eke out an existence from drylands.

Building confidence within local communities and addressing policy and institutional barriers to improvements are keys to success. The impact pathway analyses have brought awareness to the research teams of the need to properly identify barriers to the 'next' use of the project outputs, and the types of changes in knowledge, attitudes, and skills required. This helps to design projects that more effectively and accurately determine and address the pathways to up-scale research findings.

There are numerous areas where policy can promote improved dryland livelihoods while conserving the environment. Payments for environmental services are relatively new for dryland environments but offer great potential as income generators. Other options include helping to establish new markets for ecosystem services like carbon and water, subsidy schemes that help land users overcome the initial costs of changing land use and management, provision of micro-finance, etc. Provided that stakeholders develop the schemes, they could help reverse the 'investment deserts' that currently characterise drylands.

There is a role for the private sector in the regeneration of dryland environments. The private sector has become increasingly concerned over the negative image of their workforce's welfare and the environments that they operate in. Given that returns on investments in marginal areas like drylands utweigh those obtained from other relatively high productivity areas, the private sector now views drylands more favourably than in the past. There is a realisation that much of our needed increases in food production will have to come from smallholder farms rather than large scale farms, thus opening up the possibilities for private-public partnerships to drive economic growth and job creation in drylands and other previously neglected areas. The most successful example of this in the SUMAMAD project can be seen in the Chinese case study in the Hunshandake Sandlands (see Box 4).

Photo Credit: UNESCO

A Constellation of Dryland Centres

BHA: Altiplano Highlands, BOLIVIA

MAH: Mare aux Hippopotames Biosphere Reserve, BURKINA FASO

ZKW: Zeuss-Koutine Watershed, TUNISIA

OBR: Omayed Biosphere Reserve, EGYPT

RJS: Western Rajasthan, INDIA

DBR: Dana Biosphere Reserve, JORDAN

GBP: Gareh Bygone Plain, ISLAMIC REPUBLIC OF IRAN

LSR: Dingarh/Lal Sohanra Biosphere Reserve, PAKISTAN

HSL: Hunshandake Sandland, CHINA

Photo Credit, UNESCO

Highlands (Altiplano), *Bolivia*

OVERVIEW: The Bolivian Altiplano is a fragile, high altitude, semi-arid and arid ecosystem. Quinoa crops have been grown historically in the region for sustenance, but have recently become an international cash crop. However, the altiplano's fragility does not allow for non-traditional intensive cropping, and when combined with threats of climate change, vulnerable quinoa producers need better climate and agronomic information and practices for resilient livelihoods.

Institutional Arrangements

Lead Institution: Institute of Agricultural Research and Natural Resources, Faculty of Agronomy, Universidad Mayor de San Andres (La Paz)

Team Leader: Dr. Magali Garcia Cardenas

Partner Institutions: K.U. Leuven University, Division of Bioeconomics and Soil and Water Management, Heverlee, Belgium

Environmental Conditions

The Bolivian Highland (Altiplano) is high altitude plateau (800 km long and 120-160 km wide), with an average altitude of 4,000 m and total area of 123,000 km^2. Due to its equatorial proximity, the Altiplano is one of only a few areas globally where agriculture can be practiced at 3,500 metres above sea level. However, it is a fragile ecosystem, classified as arid and semi-arid with a highly variable climate and weather system. The rainy season is very concentrated and paired with long dry spells. Low temperatures, periodic droughts, flooding, and severe frost are characteristic of the region. Also, soils are shallow, poor in organic matter, slow to develop, and sensitive to erosion.

Socio-economic Conditions

A majority of Bolivia's population lives in the Altiplano. Outside of the city there are many rural farmers who depend primarily on agriculture and family labour for their livelihoods. The majority live in small family holdings and traditional-technology farms. The farmers have historically used local ecological knowledge and diverse agricultural production systems to deal and manage with the uncertainty and risk of the climate in this region. This has been successful due to their highly organized systems and relationship with the environment. However, while adaptability has served them well in the past, they will need a new framework to deal with changes in both the market and climate. Per capita income is about $3200 US/year.

Main Challenges

In the Altiplano of Bolivia, SUMAMAD II project activities were designed to address the following major challenges:

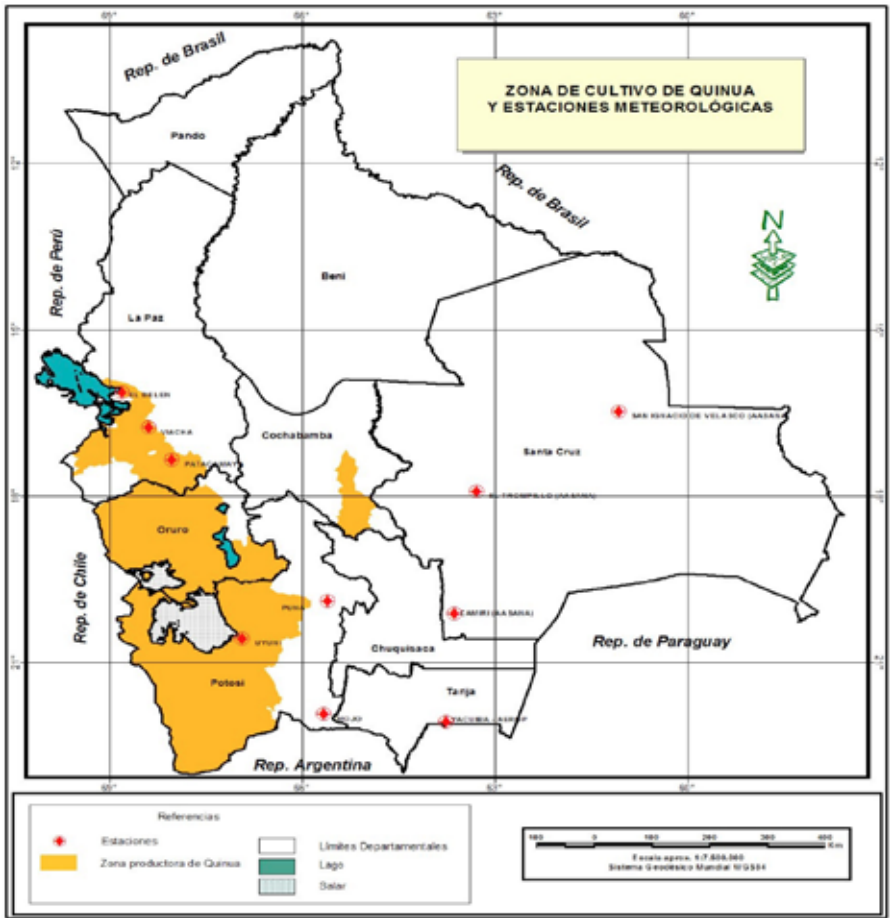
- Climate change: models predict longer dry seasons and more frequent storm events, which is already leading to the abandonment of traditional crop rotations and production strategies;
- Changing market conditions: agro-ecosystems are becoming intentionally less diverse due to increasing demand for quinoa as a cash crop, increasing monoculture crop dependency and reducing food security;
- Historically low yields of quinoa have led to agricultural expansion into 'new lands', often resulting in their erosion and degradation;
- Market insertion and participation is currently poor amongst farmers;
- Changes to demographic and social structure and economic developments (including migration from rural to urban areas);
- Lack of proper evaluation and understanding of reasons for recent changes to the production system.

Photo Credit: Natasha Lazic, UNESCO

Major Achievements

The SUMAMAD project team was able to achieve the following:

- National seminars were held annually, contributing to capacity building and raising awareness for quinoa farmers, stakeholders, and decision-makers;
- Several academic and non-academic publications (including manual and technical handbooks, and graduate and doctoral theses) promoting sustainable livelihoods and agriculture;
- Production of a cropping calendar for optimal, sustainable, and adaptable quinoa production;
- Assessment of the climate to determine climatic constraints on quinoa resulted in an agroclimatic manual;
- Fertilizer applications and novel irrigation techniques such as deficit-irrigation were evaluated, and best practices suggested from results;
- Measurements of microbiological activity induced by manure incorporation were taken, and best timing to achieve optimal mineralization rates for localized conditions was determined.



Mare aux Hippopotames Biosphere Reserve, *Burkina Faso*

OVERVIEW: Burkina Faso is a landlocked developing country in West Africa. It is one of the poorest countries in Africa and has a dry tropical climate characterized by a short rainy season and long dry season. The economy is based on agriculture and cattle breeding. The concentration of "environmental refugees" in the south of the country resulted in the establishment of a forested biosphere reserve in 1987 (Réserve de biosphère de la Mare aux Hippopotames). Poverty has driven the local populations around the reserve to exploit whatever resources they can and has resulted in land and water degradation and loss of biodiversity. The project focused on alternative livelihoods options including agro-silvo-pastoral systems (especially for women) and scenarios for future land use change under climate change.

Institutional Arrangements

Lead Institution: Centre National de la Recherche Scientifique et Technologique (CNRST), Ouagadougou, Burkina Faso

Team Leader: Dr. Jean-Noël Poda

Partner Institutions: Inter village association of natural resources and fauna in the Hauts-Bassins (AGEREF-HB); the National Department of Protected Areas (OFINAP); Ministry of Secondary and Higher Education (MESS), University of Ouagadougou, Polytechnical University of Bobo-Dioulasso, Ministry of Environment and Sustainable Development (MEDD)

Environmental Conditions

The "Réserve de biosphere de la Mare aux Hippopotames" is located between the latitudes 11° 30' and 11° 45' north, and longitudes between 04° 05' and 04° 12' west, with a Sudanese climate receiving 800 mm annual rainfall. There has been a climatic shift in the isohyets of about 50 km south, resulting in increasing aridity and population migration. The combination of changing climatic conditions and land mismanagement through overgrazing, burning, and unsustainable cotton production has resulted in desertification.

Socio-economic Conditions

With a GDP of only US$240 per capita/year and a poverty incidence of 45%, Burkina Faso is one of the poorest countries in Africa. The economy is based on agriculture, mainly food grains, sesame seed, mango, and citrus fruits, with cotton and cashews as export crops. The biosphere reserve includes five riparian villages. The population around its agricultural hub in Bobo-Dioulasso is increasing with a return of migrants from neighbouring Côte d'Ivoire.

Photo Credit: Richard Thomas, UNU-INWEH

Photo Credit: UNESCO

Main Challenges

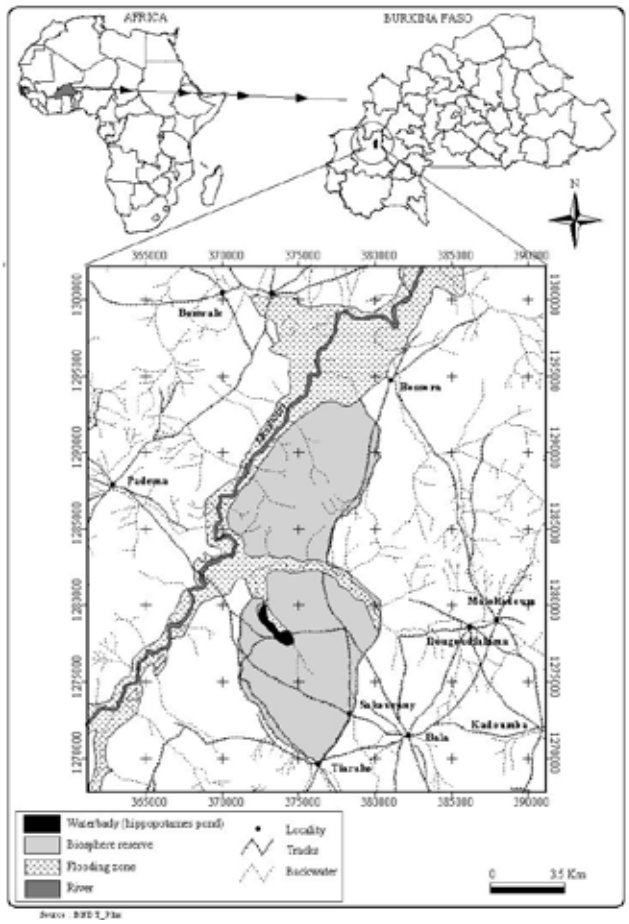
In the Mare aux Hippopotames Biosphere Reserve, SUMAMAD II project activities were designed to address the following major challenges:

- Reversing land degradation that has resulted from land mismanagement including unsustainable cotton production with resulting environmental pollution;
- Development of viable alternative livelihoods that increase income generation through diversification of production systems while preventing further land degradation and biodiversity loss.

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Agroforestry pilot farms and demonstration sites with fruit bearing trees;
- Consolidation of the local NGO community (AGEREF) comprised of farmers, animal breeders, fishers, hunters, women, and mutual associations;
- Increased facilities for eco-tourism;
- Introduction of income generating activities including non-wood forest products, fishing, apiculture, and tourism;
- Inventory of forest fauna and flora biodiversity.



Hunshandake Sandland, *China*

OVERVIEW: Located in the middle of Xilin Gol Plateau, Inner Mongolia and close to the Xilin Gol Biosphere Reserve, Hunshandake is one of the four major sandlands in China. It is well known as a source of dust storms that blow in from the north towards Beijing and Tianjin. Project activities focused on environmental monitoring, natural re-growth of grasslands, the introduction of chicken farming as an alternative land use, and income and employment generation. Adding value to animal products has also been studied within an integrated and holistic framework.

Institutional Arrangements

Lead Institution: Institute of Botany, Chinese Academy of Sciences, Xiangshan, Beijing, China

Team Leader: Prof. Jiang Gaoming

Partner Institutions: Chinese Man and the Biosphere (MAB) National Committee; Environmental School of Beijing University; Inner Mongolia University; Institute of Zoology at the Chinese Academy of Science; Agriculture University of Mongolia

Environmental Conditions

Hunshandake is located in a semi-arid grassland ecosystem encompassing a wide range of habitats such as sparse elm forests, lowlands, hills and wetlands. The main soil type is Aeolian sandy soil. In the Hunshandake area, monthly temperatures range from –18.3 °C in January to +18.5 °C in July. Most of the annual precipitation (250 to 400 mm) falls during the summer months with little inter-annual variability between the years.

Socio-economic Conditions

Hunshandake has a population of 128,000 people, 40% of whom are Mongolian. About two thirds of the population live in rural areas and depend mainly on livestock production for their livelihoods. The animals raised in the area are comprised of cattle, sheep, and increasingly in recent years, goats.

Main Challenges

In the Hunshandake Sandlands, SUMAMAD II project activities were designed to address the following major challenges:

- Severe sand and grassland degradation, resulting in severe dust storms with effects in areas far away from the source;
- Land degradation caused by overgrazing of cattle, goats and sheep.

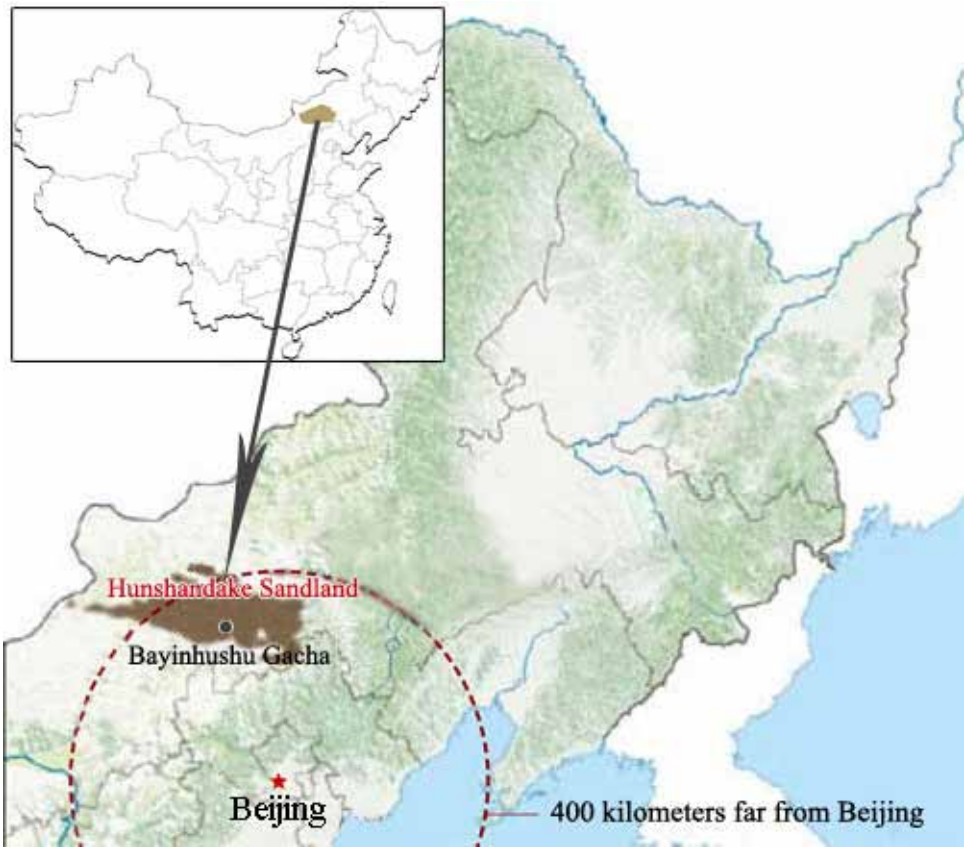
Photo Credit: UNESCO

Photo Credit: UNESCO

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Remarkable natural restoration of severely degraded sandlands: Three-fold increase in above ground plant biomass in chicken farmed land compared with sheep grazing. Root biomass increased by 60% in fenced chicken paddocks when compared with sheep grazed land. Potential for carbon payments identified;
- Introduction of chicken farming as an alternative livelihood to cattle farming, yielding a six-fold increase in economic return;
- Outstanding uptake of policy recommendations provided by the study site; part of a US$5 billion investment by the Chinese government in restoring grasslands;
- Successful advocacy for substantial investments in enhancing local road infrastructure;
- Publication of twelve scientific research papers;
- Extensive media coverage at national and international levels.



Omayed Biosphere Reserve, *Egypt*

OVERVIEW: The Omayed Biosphere Reserve (OBR) is located in the north western part of Egypt stretching along the Mediterranean coast for a length of 35 km, covering an area of 75,800 ha and ranging from 0 to 100 m above sea level. The site was designated as a UNESCO biosphere reserve in 1981, but rapid urbanization is occurring along the coast line and threatening the integrity of the reserve. The SUMAMAD project focused on ecosystem services and land use change scenarios, rehabilitation of degraded ecosystems, and generating employment opportunities for local communities, particularly women.

Institutional Arrangements

Lead Institution: Department of Environmental Sciences, University of Alexandria, Alexandria, Egypt

Team Leader: Prof. Boshra Salem

Partner Institutions: Egyptian National Commission for UNESCO; Egyptian National MAB Committee; Omayed Biosphere Reserve; Institute of Social Research of Tanta University; Clear Water Solutions; Mubarak Scientific City at Burg El Arab

Environmental Conditions

The OBR is located in a warm desert and semi-desert ecosystem. Habitats range from littoral calcareous dunes to inland ridges with skeletal shallow soils, saline marshy and non-saline depressions, an inland plateau, pasture land and fig plantations. Its climate has been described as “sub-deserted warm temperate climate” with a rainy season in winter and dry, hot summers. Water resources in the area are very scarce, which led to the creation of an irrigation canal from the Nile River.

Socio-economic Conditions

The OBR is home to about 5,500 people who are mainly nomadic and semi-nomadic Bedouins, though in recent decades they have become sedentary in some areas. In general, living standards of Bedouin communities are low due to water scarcity, limited access to social services and lack of infrastructure. For their livelihoods people depend on raising sheep, intensive quarrying, and some rain-fed cultivation of grain crops (barley), vegetables, and orchards. Irrigated agriculture has recently become an option, since a canal now links the region with the Nile Delta. Animal husbandry, i.e., the raising of sheep, generates the highest economic revenues.

Major Challenges

In the Omayed Biosphere Reserve, SUMAMAD project activities were designed to address the following major challenges:

- The development of tourism infrastructure that has affected fresh water aquifers;
- Groundwater pollution caused by seawater intrusion and by sewage from septic tanks;
- Rangelands degradation and destruction of wildlife habitats caused by overgrazing, woodcutting, soil salinization, and introduction and/or expansion of agroforestry systems;
- Shifts from traditional nomadic patterns to sedentary lifestyles coupled with overall population growth.

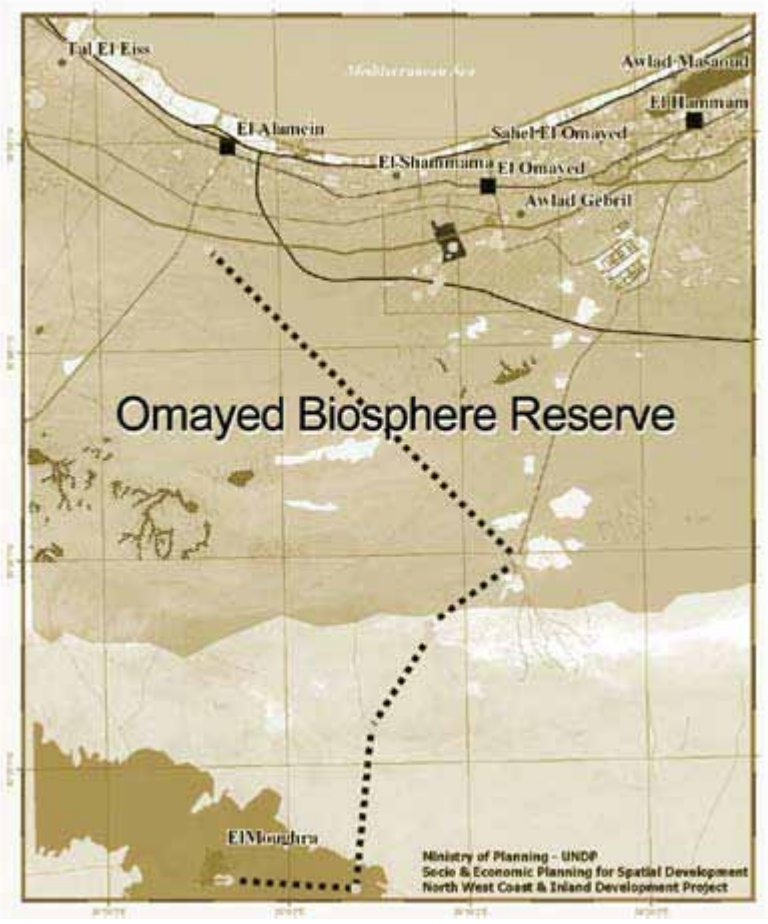
Photo Credit: UNESCO

Photo Credit: UNESCO

Main Achievements

The SUMAMAD project team was able to achieve the following:

- Participatory GIS database of OBR identifies use zones for the benefit of the local community;
- Scenarios for future land use changes as affected by climate change identified with stakeholders;
- An assessment of natural resources in the Moghra Oasis and techniques to re-vegetate areas with indigenous plant species;
- Installation of 30 solar powered desalination units to provide drinking water established in three local communities in OBR;
- A microcredit scheme allowed Bedouin women to engage in income-generating activities based on sewing in 5 villages;
- Olive propagules distributed for alternative income generation for men;
- Postgraduate training for members of the SUMAMAD team.



Thar Desert, Western Rajasthan, *India*

OVERVIEW: The arid region of Western Rajasthan known as the Thar Desert covers an area of over 196,000km^2. Populations are poor with a per capita income of around US$450 per annum. Most villages engage in mixed crop-livestock systems, but development in these communities is held back by low literacy and income rates, combined with low, erratic rainfall. Overgrazing has resulted in land degradation and a lack of water restricts crop production to relatively small areas with permanent pastures, which is the dominant land use. The SUMAMAD project focused on rehabilitating rangelands and introducing new agroforestry options.

Institutional Arrangements

Lead Institution: Central Arid Zone Research Institute, Jodhpur, India

Team Leader: Dr. A.K. Sikka, Dr. T.K. Bhati, and M.M. Roy

Partner Institutions: Farmers from the villages of Bharamsar, Bujawar and Rohila Kalanare

Environmental Conditions

Western Rajasthan is an arid region receiving 100-450 mm of annual rainfall. Drought is a recurring feature of the region with most rainfall occurring in the short monsoon season of July-September. Soils are low on organic matter (<0.45%) and are susceptible to wind and water erosion. Water harvesting is practiced mainly via ponds (nadis) and is crucial for crop production. Traditional animal husbandry practices rely on free access to uncultivated lands with post-harvest grazing of crop residues.

Socio-economic Conditions

Villages have low literacy rates of <36% with per capita income ranging from US$360-530 per annum. There is low awareness of options for agricultural improvements.

Major Challenges

In the Thar Desert, SUMAMAD project activities were designed to address the following challenges:

- Stabilize and increase the resilience of crop-livestock systems in order to provide income in a highly degraded environment;
- Introduce new crop and agroforestry options.

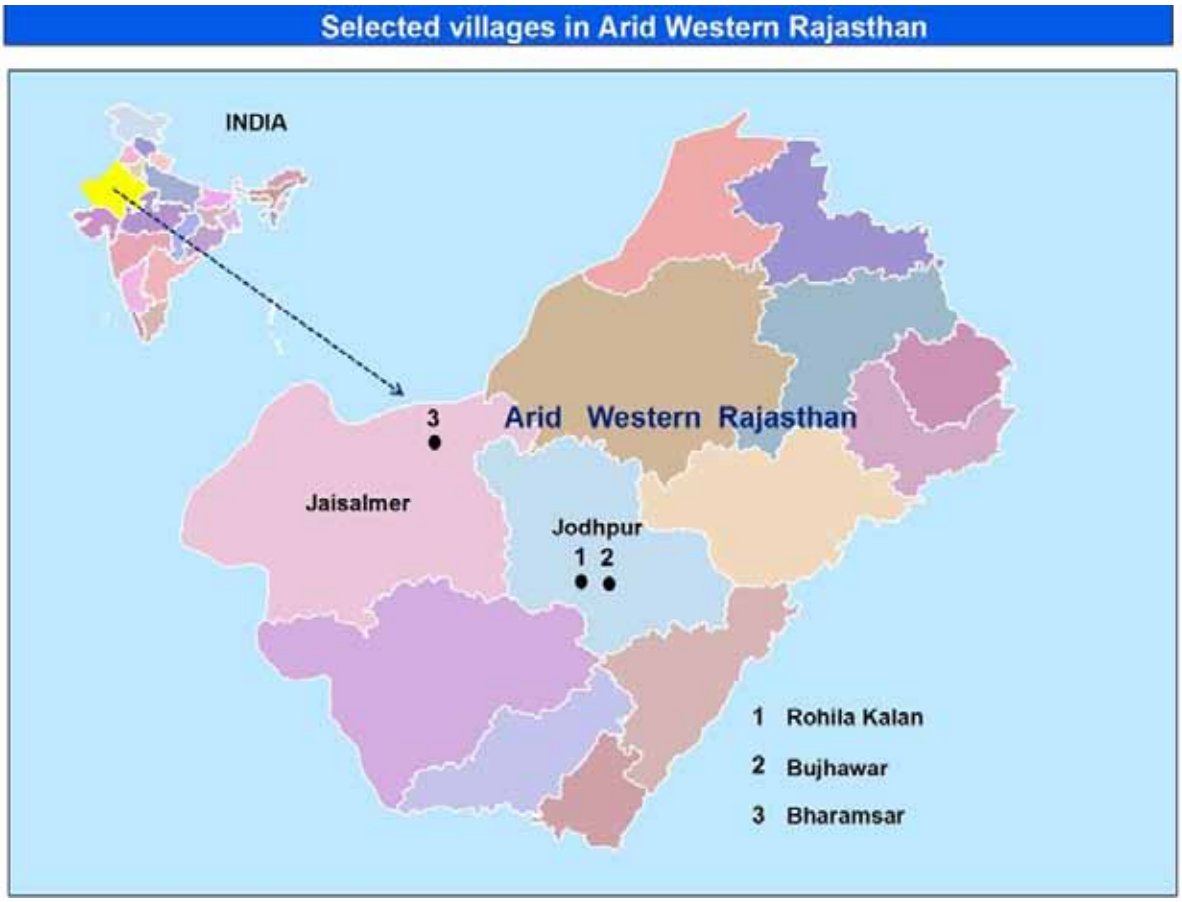
Photo Credit: Richard Thomas, UNU-INWEH

Photo Credit: Richard Thomas, UNU-INWEH

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Development of action plans for alternative income generation in the target villages;
- Establishment of Gum Arabic production, farmers' nurseries and composting of farm waste;
- Introduction of improved crop and tree cultivation techniques using harvested water or run off farming (Khadin);
- Recommendations were made for the preservation of sacred groves (orans) and their biodiversity;
- Urea enrichment and mineral feed blocks introduced to improve animal feeds.



Gareh Bygone Plain, *Iran*

OVERVIEW: The undulating area southwest of the Gareh Bygone Plain in Iran is a marginal rangeland used by nomadic farmers. The rangelands have been degraded and populations have been migrating out. The project has focused on ecosystem studies, capturing erratic rainfall by designing flood water spreading systems, organizing local cooperatives, and introducing the findings to national policy makers. A range of alternative income generating activities was tested, including poultry, vegetable, apiculture, and fruit production.

Institutional Arrangements

Lead Institution: Fars Research Centre for Agriculture and Natural Resources, Shiraz, Iran

Team Leaders: Mansour Esfandiari Baiat and Mehrdad Mohammadnia

Partner Institutions: University of Shiraz; Shiraz Medical University

Environmental Conditions

The Gareh Bygone Plain is in an arid region with a mean annual precipitation of 250 mm and high temporal and spatial variation of rainfall. A few brackish water holes provide water for wildlife and livestock. The soils are predominantly aridisols and entisols, consisting mainly of loose sand. Phyto-geographically, the Gareh Bygone Plain is located between two major habitats of Irano-Turanian domain and the Persian Gulf-Oman group.

Socio-economic Conditions

There are four villages in the Gareh Bygone Plain with a total population of 2,127 people, who are mainly trans-humant nomads (figures from 2003). About two thirds of the households in the Gareh Bygone Plain live below the poverty line, while the rest is not much better off. Most of the people depend on agriculture for their livelihoods. The bulk of the income is generated through agro-pastoral land uses comprised of the cultivation of wheat, barley, cotton, sugar beets, alfalfa, tomatoes, cantaloupe, and watermelons, as well as the herding of sheep and goats. Beekeeping is also becoming increasingly important.

Main Challenges

In the Gareh Bygone Plain, SUMAMAD project activities were designed to address the following major challenges:

- Recurring droughts and declining freshwater resources resulting in food security challenges;
- Overgrazing, fuel wood collection, unsustainable hunting levels, and application of inappropriate technologies causing rangeland degradation;
- Salt water intrusion in alluvial aquifers;
- Soil salinisation problems caused by irrigation with saline water;
- Out-migration of people from areas affected by dust storms to urban centres.

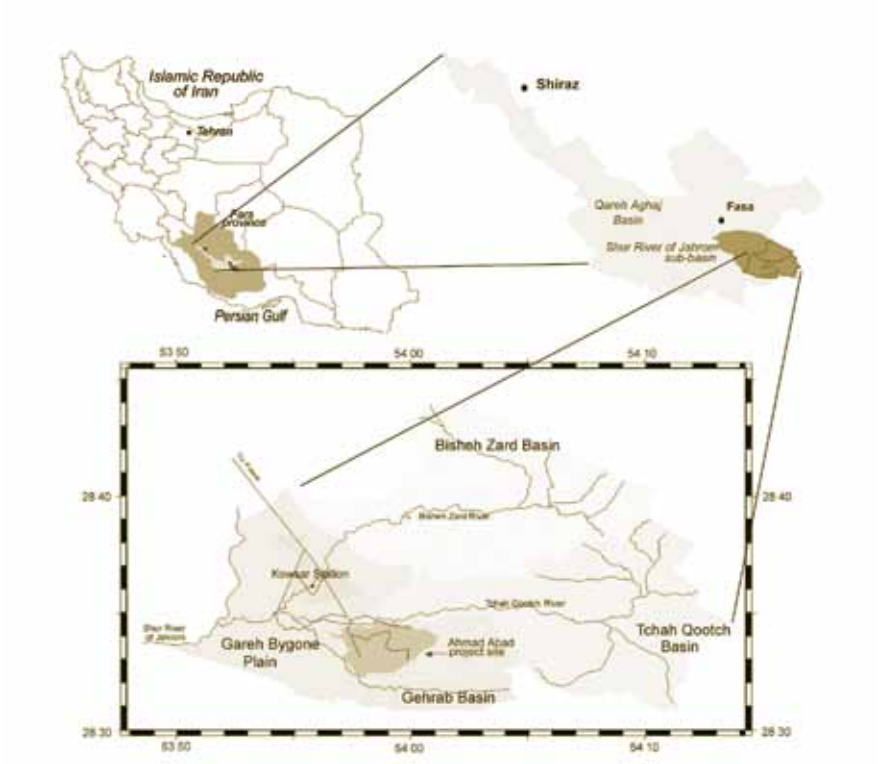
Photo Credit: UNESCO

Photo Credit: UNESCO

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Policy-makers allocated funds for scaling up the aquifer management and recharge technologies tested by the SUMAMAD team on 1.5 million ha of degraded rangeland;
- The artificial recharge of aquifers and enhanced water-use efficiency provided the basis for an eight-fold increase in the area of perennially irrigated farm fields;
- The marketing of honey provides additional income to local people, while eco-labelling is being pursued for added value;
- Enhanced carbon sequestration by spate-irrigated tree plantations;
- Enhanced forage yield (five–fold increase) by introducing spate-irrigation to rangelands;
- The economic analysis of 15 alternative income generating activities identified propagating medicinal and ornamental plants, shifting agriculture to home gardens and glasshouse production of tomatoes with benefit:cost ratios demonstrated to be greater than 1.5.



Dana Biosphere Reserve, *Jordan*

OVERVIEW: The Dana Biosphere Reserve (DBR) is a prominent landmark situated in a mountainous region with the Dana Valley. It covers an area of 30,800 ha, ranges from 100 to 1500 m above sea level, and was designated as a reserve in 1998. Project activities focused on integrating biodiversity conservation with socio-economic development in primarily pastoral production systems. Local herder communities were mobilized to develop plans for sustainable management of the degraded pasture land.

Institutional Arrangements

Lead Institution: The Royal Society for the Conservation of Nature, Amman, Jordan

Team Leader: Mr. Maen Smadi

Environmental Conditions

The Dana Biosphere Reserve is located in an arid to semi-arid ecosystem and is comprised of a wide range of habitats including semi-arid forests, mid-altitude steppe with shrubs, Acacia subtropical habitats, and sand-dune deserts. The climate varies from the eastern high lands, where altitudes reach 1,600 m, to the western low-lands with an altitude of only 100 m. The climate in the high lands is characterized by cold winters and average monthly temperatures ranging from -10 °C to +15 °C. Annual rainfall varies from 100 to 350 mm.

Socio-economic Conditions

24,900 people live adjacent to the protected area. Farming activities, government jobs, and employment in nearby factories are the major sources of income for the villagers settled around the reserve. The Bedouins concentrated in the western lower areas around the reserve still depend on livestock grazing and use the reserve as a grazing area for their animals. The creation of the Dana Biosphere Reserve provides limited employment opportunities for local communities related to tourism development.

Main Challenges

In the Dana Biosphere Reserve, SUMAMAD project activities were designed to address the following major challenges:

- Overexploitation of natural resources including over-grazing, wood collection, and hunting;
- Large areas of unsuitable drylands used for agriculture;
- Over-pumping of water causing continued decline in the level of aquifers and increased soil salinity;
- Overuse of chemical fertilizers.

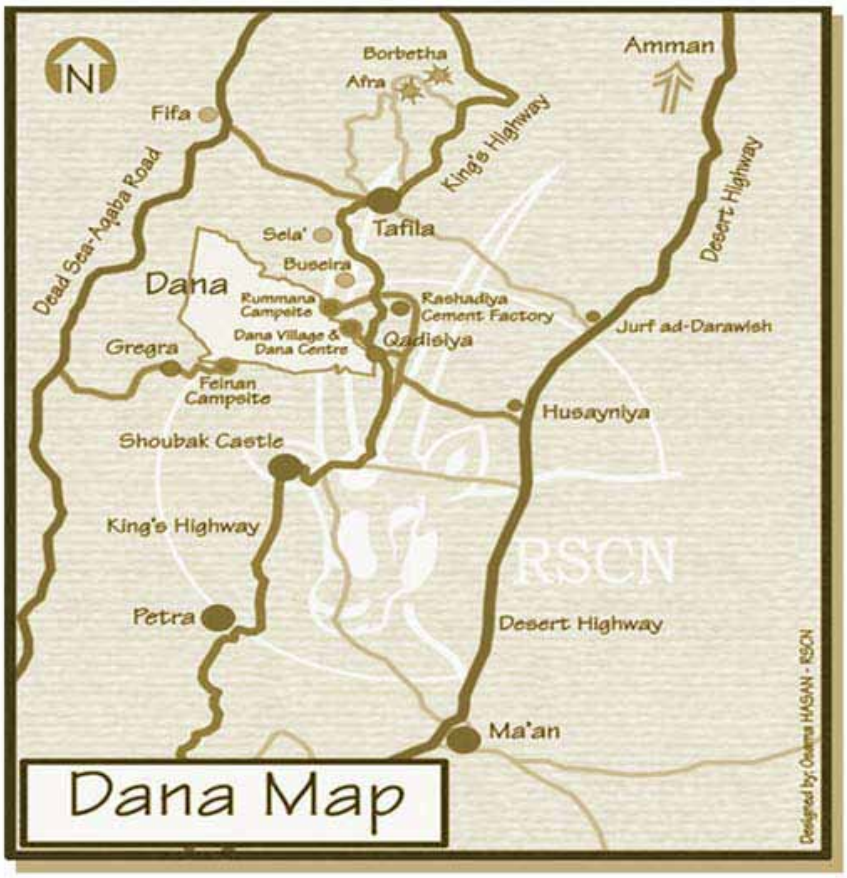
Photo Credit: UNESCO

Photograph: UNESCO

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Professional marketing and packaging of traditionally produced olive oil soaps increasing the income of olive oil farmers and women involved in the production;
- Establishment of an eco-tourism lodge that is almost entirely managed by local people and has created additional employment opportunities;
- A water-efficient irrigation system which has enhanced the productivity in village orchards established on traditional stone terraces;
- An action plan was developed by a cooperative of livestock owners for improved use of water sources and rangeland based on land use scenarios.



Dingarh/Lal Sohanra Biosphere Reserve, *Pakistan*

OVERVIEW: The Lal Sohanra Biosphere Reserve was designated as a biosphere reserve in 1997, and covers an area of 65,791 ha. In the adjacent Cholistan Desert, SUMAMAD project activities focused on soil and water conservation, the establishment of saline fish ponds, and the rehabilitation of degraded rangelands through water management and deferred grazing options.

Institutional Arrangements

Lead Institution: Pakistan Council of Research in Water Resources, Bahawalpur, Pakistan

Team Leaders: Dr. Muhammad Akram Kahlown and Zamir Ahmed Soomro

Environmental Conditions

The Lal Sohanra Biosphere Reserve is located in a warm desert and semi-desert ecosystem. The vegetation in the project area is adapted to the arid conditions and grows sparsely in subtropical thorn forests and the Cholistan desert habitat. There are also a limited number of freshwater wetlands in the reserve. The soils are moderately calcareous, predominantly consisting of sandy deposits, and severe salinity and sodicity problems exist. The climate of the area is arid subtropical and continental, characterized by low and sporadic rainfall, and high temperatures. The study area is one of the driest and hottest areas in Pakistan, with annual rainfall varying between 100 and 250 mm.

Socio-economic Conditions

The human population residing in and adjacent to the Lal Sohanra Biosphere Reserve encompasses many different ethnicities with different characteristics, languages, and customs. The total human population of the project site is more than 4,000 people, whose main livelihood (70%) is livestock rearing, particularly sheep, goats, cattle, and camels. Off-farm work, marketing of local handicrafts, and farming on the periphery of the desert represent additional sources of income.

Main Challenges

In the Lal Sohanra Biosphere Reserve SUMAMAD project activities were designed to address the following major challenges:

- Extreme water scarcity limiting the area of irrigated agriculture;
- Rangelands degradation caused by uncontrolled grazing systems;
- Limited access to markets and processing industry for livestock products (e.g., milk, hides, meat, leather, wool);
- Limited infrastructure for communication and transportation;
- Lack of alternative livelihoods other than livestock rearing.

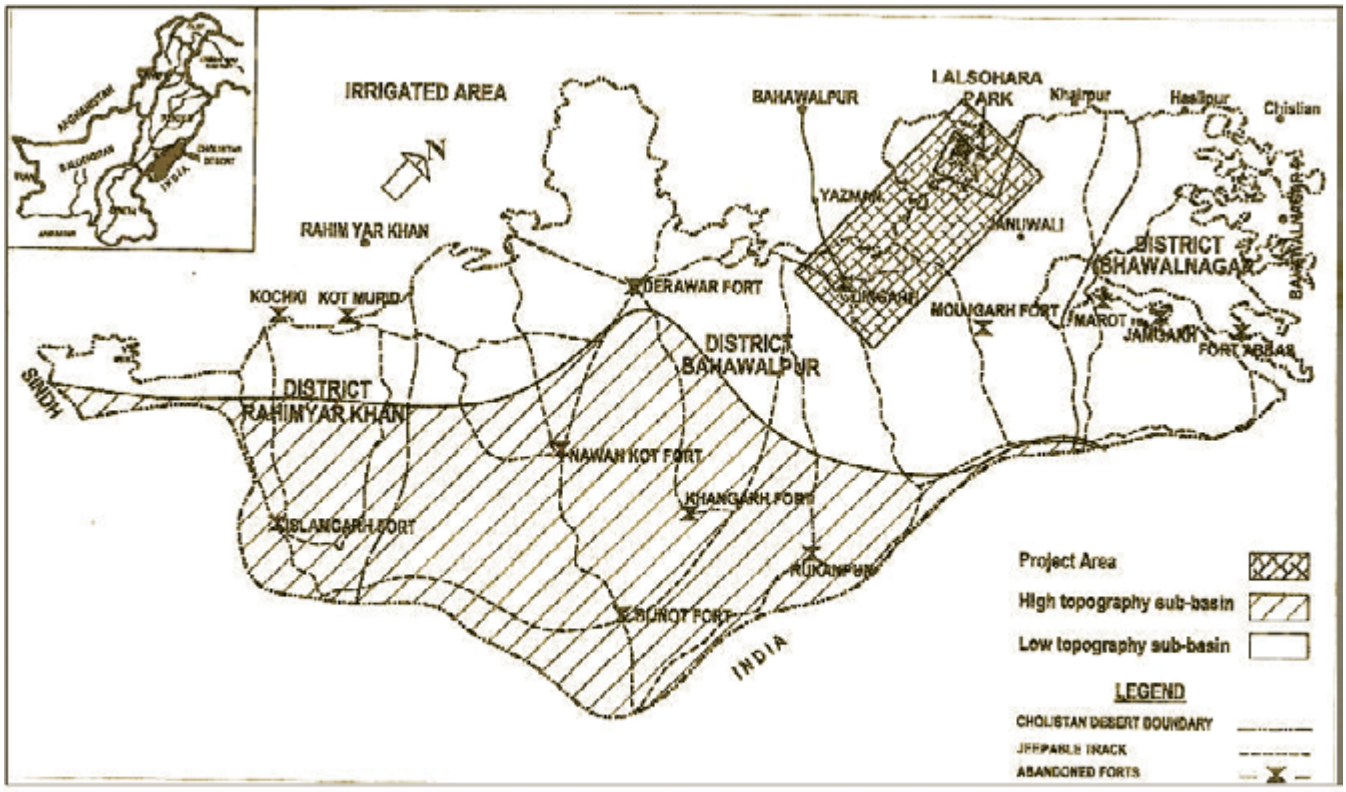
Photo Credit: UNESCO

Photo Credit: Richard Thomas, UNU-INWEH

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Saline fish farming using the largely untapped potential of available brackish water resources, proved to be an economically successful, alternative livelihood for local communities;
- The cultivation of vegetables using rainwater and saline groundwater providing additional income to local people;
- A combination of rainwater harvesting and sand filter technology enhances the availability of fresh water both for human consumption and sheep farming;
- A 'boundary organization" was established including government and research organizations and local communities that has developed guidelines for better management of water and rangeland resources.



Location Map of the Lalsohara Biosphere and Cholistan Desert

Zeuss-Koutine Watershed, *Tunisia*

OVERVIEW: The watershed of Zeuss-Koutine is situated in south-eastern Tunisia, north of the city of Medenine. The region has experienced increasing anthropogenic pressure since the 1960's, resulting in environmental degradation manifested by natural vegetation cover reduction, overuse of water resources, and poor and eroded soils. The SUMAMAD project focused on increasing groundwater recharge of depleted aquifers, rehabilitation of degraded vegetation, future land use scenarios, and alternative income generation by adding value to aromatic and medicinal plants and stimulating eco-tourism.

Institutional Arrangements

Lead Institution: Institut des Régions Arides (IRA), Médenine, Tunisia

Team Leader: Dr. Mohamed Ouessar

Partner Institutions: Institut de l'Olivier-Zarzis; Commissariat Régional au Développement Agricole in Médenine; Association des Jeunes de Zammour in BéniKhédache; Association des Amis de la Terre in Tataouine; Association de la Protection de la Biodiversité in BéniKhédache; Association de Sauvegarde de la Nature et de la Protection de l'Environnement à Douiret in Tataouine; Union Tunisienne d'Aide aux Insuffisants Mentaux – Section de Médenine

Environmental Conditions

The Zeuss-Koutine watershed of southeastern Tunisia is characterized by steppe vegetation in an arid climate. There are also some Wadi beds and watercourses with distinct species compositions. Total rainfall is low (150 to 240 mm) and highly irregular. Temperature differences are extreme between the seasons, ranging from -3 °C up to +48 °C.

Socio-economic Conditions

Approximately 1 million people live in the Jaffara. Despite problems of desertification and water scarcity, the agri-cultural sector remains the major source of income in the area. Olive production represents the main agricultural activity, but the cultivation of cereals and the traditional breeding of camels and small livestock also contribute to livelihoods.

Main Challenges

In the Zeuss-Koutine watershed, SUMAMAD project activities were designed to address the following major challenges:

- Frequent periods of serious droughts;
- Floods causing soil erosion;
- Overgrazing in rangelands;
- Land uses competing for limited water resources;
- Poverty, unemployment, and emigration.

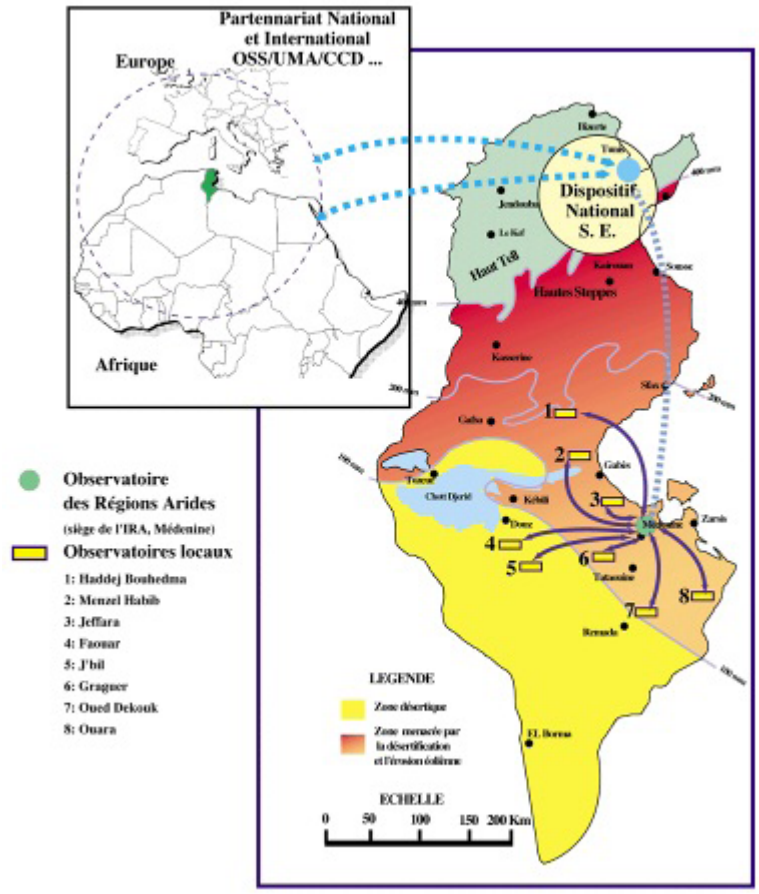
Photo Credit: UNESCO

Photo Credit: UNESCO

Major Achievements

The SUMAMAD project team was able to achieve the following:

- Optimized use of the olive oil waste water or 'margins' for soil stabilization and fertility improvement;
- Alternative groundwater recharge structures (recharge wells) were tested;
- Better understanding of the role of water harvesting in flood prevention;
- Most appropriate rangeland rehabilitation practices were identified and evaluated;
- Local action plans for combating desertification put in place for BéniKhédache (Médenine);
- Economic diversification in participating communities through the establishment of ecotourism facilities was linked with the marketing of sand-based handmade crafts;
- Value was added to local production of aromatic and medicinal plants;
- The capacity of the SUMAMAD team was enhanced through post-graduate education and skills training.



SUMAMAD Publications

SUMAMAD publications can be found on UNESCO's website at:

http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/specific-ecosystems/drylands-desertification/sumamad/publications/

Innovative ways for a sustainable use of drylands. **Final report of the SUMAMAD project.** Published by UNESCO, 2013.

People in Marginal Drylands: Managing Natural Resources to Improve Human Well-being **A policy brief based on the Sustainable Management of Marginal Drylands (SUMAMAD) project.** Adeel, Z., King, C., Schaaf, T., Thomas, R., and Schuster, B., 2008. United Nations University - Institute for Water, Environment and Health. Hamilton, Canada.

Workshop Reports:

- *1st Project Management Workshop* (Cairo, Egypt; Sept. 2002)
- *2nd Project Workshop* (Shiraz, I.R. of Iran; Nov. 2003)
- *3rd Project Workshop* (Djerba, Tunisia; Dec. 2004)
- *4th Project Workshop* (Islamabad, Pakistan; Jan. 2006)
- *5th Project Workshop* (Aleppo, Syria; Nov. 2006)
- *6th Project Workshop* (Xilinhot, China; Sept. 2007)
- *Planning Workshop for 2nd Phase* (Amman, Jordan; June 2008)
- *7th Project Workshop* (Jodhpur, India; Nov. 2009)
- *8th Project Workshop* (Alexandria, Egypt; Nov. 2010)
- *9th Project Workshop* (Bobo Dioulasso, Burkina Faso; Dec. 2011)
- *10th Project Workshop* (La Paz, Bolivia; Nov. 2012)
- *11th Project Workshop* (Ghent, Belgium; June 2013)






References

[1] United Nations, 2011. *Global drylands: A UN system-wide response*. United Nations Environment Management Group.

[2] ELD Initiative, 2013. T*he rewards of investing in sustainable land management. Interim report for the Economics of Land Degradation Initiative: A global strategy for sustainable land management*. ELD Initiative.

[3] WBCSD, 2010. *Vision 2050: The new agenda for business*. World Business Council for Sustainable Development.

[4] MEA, 2005. *Millennium Ecosystem Assessment. Ecosystems and Human Well-being: desertification synthesis*. World Resources Institute, Washington D.C.

[5] MacDonald, A.M., Bonsor, H.C., Dochartaigh, B., and Taylor, R.G., 2012. *Quantitative maps of groundwater resources in Africa*. Environmental Research Letters, 7 (2).

[6] Davies, J., Poulsen, L., Schulte-Herbrüggen, Mackinnon, K., Crawhall, N., Henwood, W.D., Dudley, N., Smith, J., and Gudka, M., 2012. *Conserving dryland biodiversity*. IUCN, Kenya.

[7] Mortimore, M., Anderson, S., Cotula, L., Davis, J., Faccer, S., Hesse, C., Morton, J., Nyangena, W., Skinner, J., and Wolfangel, C., 2009. *Dryland opportunities: A new paradigm for people, ecosystems and development*. IUCN, Gland, Switzerland., IIED London, UK., UNDP/DDC, Nairobi, Kenya.

[8] Schaik van, L., and Dinnissen, R., 2014. *Terra incognita: land degradation as underestimated threat amplifier*. Netherlands Institute of International Relations, Clingendael, Netherlands.

[9] UNDP/UNCCD. 2010. *The forgotten billion: MDG achievement in the drylands*. UNDP and UNCCD, New York and Bonn.

[10] World Resources Institute, 2013. *Creating a sustainable food future: A menu of solutions to sustainably feed more than 9 billion people by 2050*. World Resources Report 2013-14: interim findings. WRI.

[11] Pretty, J.N., 1995. *Regenerating agriculture: policies and practice for sustainability and self-reliance*. Earthscan Pubs., London, U.K.

[12] Borrini-Feyerabend, G., Pimbert, M., Taghi Farvar, M., Kothari, A., and Renard, Y., 2004. *Sharing power: Learning by doing in co-management of natural resources throughout the world*. IIED/IUCN/CESSP/CMWG/Cenesta/SIDA/GTZ. Tehran.

[13] Douthwaite, B., Alvarez, B.S., Cook, S., Davies, R., George, P., Howell, J., Mackay, R., and Rubiano, J., 2008. *Participatory Impact Pathways Analysis: A Practical Application of Program Theory in Research-for-Development*. Canadian Journal of Program Evaluation, 22(2): 127–159.

[14] Adeel, Z., and Safriel, U., 2008. *Achieving sustainability by introducing alternative livelihoods*. Sustainability Science, 3: 125-133.

[15] Thomas, R.J., 2008. *Addressing land degradation and climate change in dryland agroecosystems through sustainable land management*. Journal of Environmental Monitoring, 10: 595-603.

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