Water in drylands

Adapting to scarcity through integrated management

Editors: Jonathan Davies, Stefano Barchiesi, Claire J. Ogali, Rebecca Welling, James Dalton, Peter Laban

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Page 14. **Case study 1:** Community members Watering livestock and fetching potable water from shallow well connected to sub-surface in Qur qura area of Garba Tula, Kenya © Yasin Mahadi S. Salah.
Page 17. **Case study 2:** Developing a sub catchment management plan, Balamabala Sub County, Garissa © Dr. Ahmed Mohamed.
Page 19. **Case study 3:** Local farmer still using old unsustainable irrigation techniques (flooding), which was later replaced with drip irrigation © Lara Nassar.
Page 22. **Case study 4:** El Amatillo, border between Honduras and El Salvador © Manuel Farias / IUCN Consultant.
Page 25. **Case study 5:** Dam body initially brown as in the forefront is now lush green thanks to the project © Salman Ali.
Page 28. **Case study 6:** Participation des femmes á la construction d'un bouli. © Zabre Silvain.
Page 36. Blanscape / Shutterstock.com

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Table of Contents

Introduction

Drylands are regions of water scarcity. However, many of the assumptions we commonly make about drylands turn out to be unfounded. For example, they are not necessarily characterized by low rainfall, some drylands in equatorial Africa may receive over 1000mm of rainfall per year on average, compared with 750mm in London and 650mm in Paris. However, these drylands have high mean temperatures and often prolonged dry seasons leading to high rates of water loss to evaporation and transpiration. It is this loss of water that determines their aridity. Drylands are also characterized by extremely high levels of climatic uncertainty; in many drylands annual precipitation can be 50% above or below the mean in the majority of years.

Dryland ecosystems and their biodiversity are uniquely adapted to these twin features of water scarcity and climatic variability. Dryland species show many remarkable adaptations to water stress, including the ability to conserve water, to extract water efficiently when it is scarce, or to survive periods without water. Some plants and animals are highly resistant to the stress of drought, some are experts in water storage or water harvesting whilst others lie dormant through long dry spells, or move to find water elsewhere (Davies et al., 2012).

Dryland societies tend to be similarly adapted to these features and have developed many ways of dealing with aridity and variability. This includes land management practices, such as cultivating drought-resistant crops or practicing mobile herding. It also includes adaptations of dryland cultures to include many practices for adaptive management and for risk management.

Dryland development has been held back in many countries due to a failure of government and non-government actors to similarly adapt policies and practices to local conditions. Policy and investment failures have slowed down development in many drylands and have left dryland communities exposed to new risks, whilst at the same time undermining their own risk management strategies. Treatment of climatic uncertainty as a problem to fix, rather than as a natural circumstance to adapt to, has fostered many poorly designed interventions. Similarly disregarding drylands as “wastelands” has led to under-investment and low aspirations for dryland areas (Mortimore et al., 2009).

This study presents some lessons from a selection of IUCN interventions in dryland areas that have adapted to a greater or lesser extent to the conditions of drylands, notably focusing on water management to deal with scarcity and variability. The study is intended as a means of capturing lessons learned from these interventions on the challenges and opportunities for improving water development in drylands. It is primarily a learning document compiled by the IUCN Secretariat, with technical advice from the Dryland Ecosystems Thematic Group of the IUCN Commission on Ecosystem Management. The document will also be shared with IUCN members and partners to catalyse deeper thinking and more effective action on water interventions in drylands as a first step in establishing improved systematic approaches and tools for influencing policy and investment regarding water management in drylands.

A general overview of key issues is provided in the first section of this study, examining the nature of drylands from both an ecological and socioeconomic point of view, the principles of ecosystem-based water management, the unique features of local governance of water and other natural resources in drylands, the challenges of managing externalities, and the need for adaptation in the face of climate change. Case studies then try to address a number of guiding questions shown in Figure 1.

Policy and management at scale	Tools and infrastructure
• How sholud we plan water interventions effectively in drylands? • How do we work at the rught scale? • What do we do differently compared with humid lands? • How do we manage dryland ecosystems most effectively to provide water-related ecosystem services?	• What infractructure and tools are best sutied to drylands? • What is best sutied to uncertainly and variability, including periodic deficits and periodic surpluses? • What technologies take into consideration the challenges of extreme temperature and high levels of evaporation?
Governance	**Stakeholders & Cooperation**
• How sholud we govern water effectively in drylands, particulary given the seasonal use, mobilty of some populations, and the vast scale of some basins? • How do we engage different stakeholders (who manages the resource, who needs it, who accesses it) • How do we build on, rather than undermine, long-standing effective management and governance systems?	• How do we mediate relationship between those in drylands and those outside drylands who share water resources? • What mechanisms exist for cooperation e.g. benefit sharing between upstream and downstream users? • What mechanisms exist for compensation? • What platforms of institutions for negotiating allocations?

Figure 1 Guiding Questions for water management interventions in Drylands

Six case studies were selected based on their location and the work they are trying to do in dryland contexts. The case studies selected were:

1. Pastoral livestock management in semi-arid and arid Northern Kenya
2. Building drought resilience in Garissa and Tana River counties in Kenya
3. Managing water effectively in the highly arid regions of Jordan
4. Building dialogue at basin-level in Mesoamerican drylands between Honduras and El Salvador
5. Restoring ancient water management systems and arresting groundwater depletion in Pakistan
6. Boosting drought risk management in Burkina Faso

These case studies have been reviewed to generate common lessons for future IUCN interventions in drylands. The lessons inform the conclusions and recommendations of this working paper, including recommendations of remaining knowledge gaps where further studies would be valuable. Lessons from the case studies are grouped into four sub-sections: lessons on integrated management of dryland ecosystems; lessons on the management of water resources and innovative technologies; lessons on governance of water at different levels; and lessons on monitoring and learning.

Drylands

Drylands cover an estimated 41% of the world's earth surface, provide 44% of the world's cultivated systems and 50% of the world's livestock while being home to a third of all humanity (MEA, 2015). Moreover, drylands hold 30% of the total area of sites of important biodiversity, 35% of the global Biodiversity Hotspot Area, and 28% of the total area of World Heritage Sites (Davies et al., 2012). In short, dryland ecosystems are important for humanity but they are underdeveloped and face major challenges, notably in terms of water management.

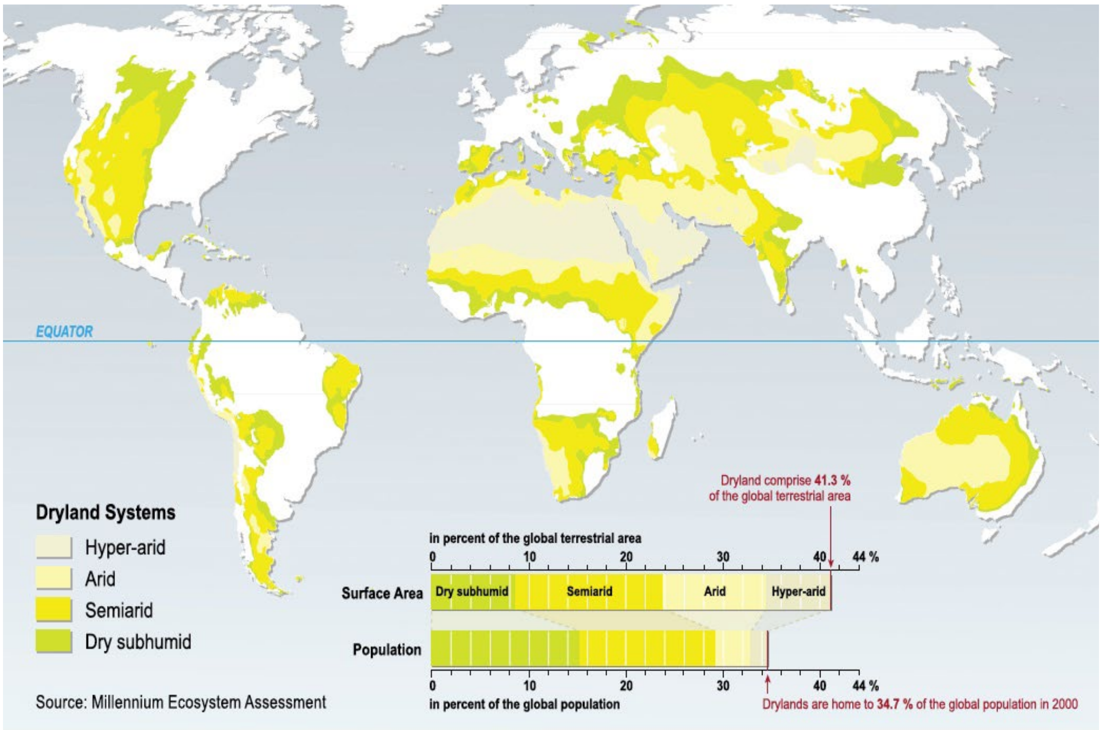


Figure 2 Global Dryland Systems

Drylands are typically categorized into four types in increasing order of aridity: sub humid, (ii) semi-arid, (iii) arid and (iv) hyper arid (Figure 2). This categorization is based on an Aridity Index (AI), which is calculated by dividing the mean precipitation by the potential evapotranspiration.

- Dry sub humid areas (the least arid drylands) have an AI of 0.65 or less, meaning that potential evapotranspiration is a little over one and half times greater than actual mean precipitation. Dry sub humid areas tend to be dominated by broad-leaved savannah woodlands with quite dense tree canopies and by perennial grasses.
- Semi-arid areas, AI=0.5, begin when potential evapotranspiration is double the mean precipitation and they are mainly dominated by thorny savannahs with a great diversity of grass species. Semi-arid areas have the highest human population densities of the drylands and as a result face particular degradation challenges.
- Where potential evapotranspiration is 5 times greater than actual mean precipitation (AI=0.2) land is classified as Arid and these areas include annual grasslands that are significantly shaped by herds of grazing ungulate species.
- Hyper arid lands have at least 20 times greater potential evapotranspiration than actual mean precipitation; they support minimal vegetation and include most of the world's deserts (Middleton and Thomas, 1997).

Unique features of dryland ecology

Drylands are characterized by water scarcity as well as unreliable and erratic rainfall, often concentrated during a relatively short rainy season (sometimes bimodal in nature), and with substantial inter-annual variation (Ellis et al., 1993). This has often resulted in inherently low levels of biological productivity (MEA, 2005), although there are significant areas of drylands with high biological productivity and diversity (Davies et al., 2012). In Bamako, Mali, total annual precipitation is 65% higher than for Paris, but it has much higher rates of potential annual evapotranspiration, and the rainfall occurs in a limited number of months, often in heavy downpours (Figure 3). This level of rainfall intensity makes it difficult, and expensive to capture the water and store it for use throughout the rest of the year. Sunk costs and high operation and maintenance expenses, combined with the natural erratic patterns of rainfall make using this water challenging without better understanding the wider natural ecosystem response to the variable hydrology.

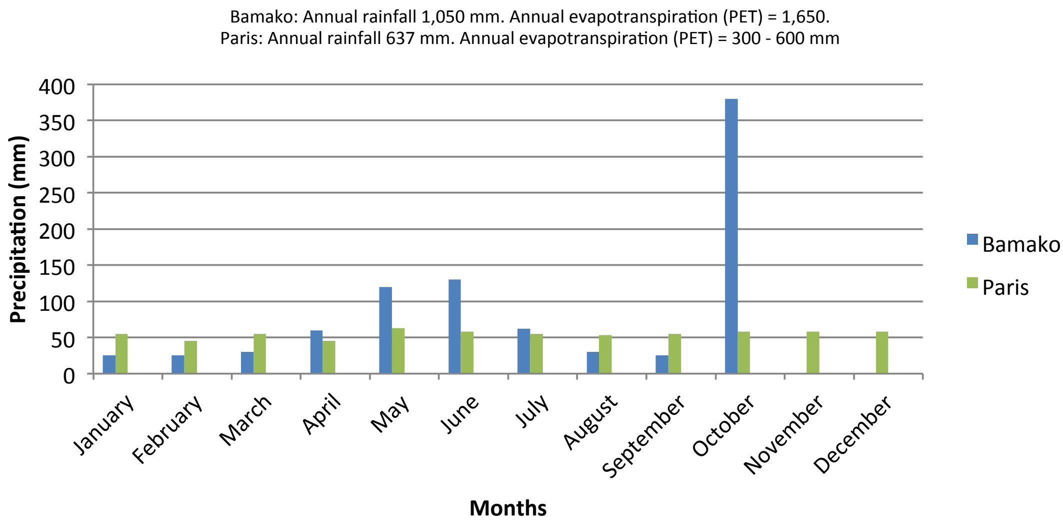


Figure 3: Precipitation Comparison for Bamako and Paris 2015

In Jordan, where rainfall levels are indeed low at around 300mm per year, annual precipitation of between 150-450mm is the norm; a difference of 1:3. In many drylands extreme years may see no rainfall at all, or levels of precipitation many times above the annual average. As a 'rule of thumb', the more arid the region the greater the climatic variability and some hyper arid areas may go years without rainfall, but then receive intense and destructive rainfall events that may be many times above mean precipitation. As a result, for their survival dryland species and ecosystems depend on efficiently harvesting and utilizing water resources.

Rainfall is also spatially highly variable, to the extent that a community in one location may receive abundant precipitation, while adjacent areas remain dry. Annual rainfall in the Rif Mountains of northern Morocco can reach 1000mm in the highest elevations, but annual rainfall is less than 250mm a few kilometres away on the leeward side of the mountains (Tayaa and Brooks 1984). Pastoralists have adapted to the resulting patchy resource endowments by systematically moving their herds according to resource availability (Davies and Hatfield, 2007).

High temperatures during the rainy season cause rapid evaporation losses, and high storm intensity frequently leads to rapid runoff and low infiltration (Brooks et al., 1997). Equally, water from low intensity rainfall can be lost through evaporation from the dry soil surface, particularly when infiltration rates are low or depressed (e.g. through loss of vegetation cover, including in terms of biodiversity, or through soil sealing). Molden and Oweis (2007) state that as much as 90 percent of the rainfall in arid environments may evaporate back into the atmosphere.

From the above it is evident that healthy dryland ecosystems depend on the way water and water flows are managed. The hydrological cycle in drylands can be characterized as providing irregular water inputs that are dependent on irregular rainfall patterns and, in general, regular water outputs in the form of regular flows of surface and especially ground water (Agnew and Anderson, 1992).

Drought is widely associated with drylands, but the concept of drought is open to misunderstanding, particularly considering the natural variability and fluctuation of precipitation in the drylands. Drought generally means a shortage in water availability and whilst aridity is a constant, drought is a temporary feature relative to the average long-term state. However, the perception of what is normal can be highly subjective. The United Nations Convention to Combat Desertification (UNCCD) defines drought as "the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems." However, this definition leaves important unanswered questions such as what represents "significantly" below normal and what duration of deficit counts as drought. Long dry periods that could be considered as "droughts" might simply be part of the dryland ecosystem features.

Other factors besides precipitation determine drought outcomes, including potential evaporation, soil types and their ability to store water, depth and presence of ground water supplies, and vegetation cover. As a result the definition of drought can vary according to location. In general there are three "types" of drought that can be experienced (UN/ISDR, 2007): meteorological; agricultural; and hydrological. Drought assessment frameworks and programmes study the propagation from the weather signal (i.e. meteorological drought) to drought in the groundwater and surface water bodies (Xerochore, 2010). Other forms of drought have also been described in the literature (e.g. pastoral drought, socio economic drought) but for the sake of simplicity the three above are expanded further to give an overview of the challenges faced by drylands, rather than to exhaustively discuss the subject.

- **Meteorological drought** is a measure of a period of dryness below a pre-determined long-term average, such as (for example) 50% below the mean for a 6 month period. Drought is determined differently according to the location, for example taking into consideration the modality of rainfall (number of rainy seasons per year).
- **Agricultural drought** is defined as insufficiency of water to meet agricultural production needs and therefore is dependent on crop-production choices. It is also determined by soil type and topography since these influence infiltration rates and moisture retention in soil.
- **Hydrological drought** refers to deficient surface and sub-surface water availability and is determined relative to water demand. Hydrological drought differs from agricultural drought due to the time lapse between precipitation deficiency and decline in ground water and reservoir levels.

The established definitions of drought are somewhat unclear on the relationship between land degradation and water shortage. Where land is degraded to the extent that water-holding capacity and infiltration rates are diminished, drought can occur during a year of average rainfall. For example, water-holding capacity is heavily reliant on soil organic carbon and therefore depleting organic carbon through poor land management leads to lower soil moisture, regardless of precipitation. Soil Organic Carbon is essentially biodiversity, including microbes, fungi and decomposing vegetation. Biodiversity loss also greatly affects infiltration rates; vegetation cover slows down surface flows, enhancing the opportunity for infiltration along root pathways which help to maintain and create macro pores in the soil structure. Vegetation cover influences the potential losses through evapotranspiration and changes in species composition could change the net loss of water to the system.

The important challenges that drylands are facing is further aggravated by the potential impacts of climate change, which is predicted to bring significant changes in precipitation and temperature patterns. Drylands may get wetter or drier, but in most cases they are projected to become more uncertain and extreme weather events are, over time, becoming more common (IPCC, 2007). Drylands are naturally resilient and adapted to climatic uncertainty, but it is unclear if dryland ecosystems will be able to cope with the increasing variability in future climate change scenarios. The impacts of climate change on water quantity and quality will vary according to the type of water resource and the location of the catchment. Surface water, groundwater, flowing and standing water ecosystems may be affected differently, although typically changes would be anticipated in water temperature, dissolved oxygen and turbidity. Different dryland ecosystems in different location, such as highlands, floodplains and rangelands, may also be affected differently.

Drylands, people and water management

Drylands are home to roughly a third of humanity and include a disproportionate share of the world's poorest people. Of the estimated 2 billion residents in drylands in 2005, 90% lived in developing countries (MEA, 2005). Poverty statistics show a legacy of under- and mal-investment in basic social services and human rights in dryland areas. For example, adult female literacy rates in West Africa are around 50% in humid areas but drop to 5% in the arid and semi-arid zones. In dryland area of Asia infant mortality rates are almost 50% above the regional mean (Middleton et al., 2011). In Ethiopia and Kenya, vaccination coverage in dryland pastoral areas is below a quarter of the coverage in other areas (Ali and Hobson, 2009).

While this study examines the suitability of water interventions in dryland area, it also recognises that in many countries a major part of the problem is the long-term inadequacy of investment in water resources management. Indeed, if this investment gap is closed without an improvement in understanding how to develop water resources adequately and appropriately in drylands, then the outcomes are likely to be detrimental to long-term sustainability. The danger is that the impact of poorly designed investments to tackle water scarcity accentuates threats to drylands. On the one hand, massive investment in water technology enables rich nations to offset this impact, whereas less wealthy nations remain vulnerable. On the other hand, investment strategies emphasizing water supply stabilization and delivery are not remedying the underlying causes of water scarcity. Moreover, they tend to incorporate some of the very factors that negatively impact biodiversity through flow distortion and habitat loss from unsustainable water resources development (Vörösmarty et al., 2010).

Drylands are not only rural areas; many of the world's biggest cities are found in dryland areas, such as Los Angeles, Karachi and New Delhi. Water supply to these urban centers is often dependent on the sustainable management of highlands and upper stretches of basins which can also and be comprised of drylands. Major rivers in East and South East Asia, including the Yellow River, Yangtse, Ganges and Mekong, all rise in the drylands of Tibet and support a population in excess of 1 billion people. It has been estimated that already over 20% of China's GDP is generated in the delta of the Yangtze River alone. The great decline of water resources and sediment flux to the sea has been a common occurrence for the two great Chinese rivers (Zao et al., 2014). Zheng et al. (2009) reported that land uses changes were predominant factors for the reduction in mean annual streamflow in the headwaters of the Yellow River basin.

Approaches to water development in dryland areas include development of groundwater resources through boreholes for domestic and productive uses, capturing more surface water in the soil, soil and water conservation, and water harvesting (Hutchinson and Herrman, 2008). Many past, and to an increasing extent current, development efforts in drylands have focused on the construction of dams and large irrigation schemes, as well as borehole construction, to improve water supply mainly for agricultural production. This is intended to capitalise on the high level of solar radiation and the potential to achieve multiple harvests per year. In Asia, the Green Revolution in the 1960s and 1970s focused to a large extent on extensive irrigation development in dryland regions. As mentioned above, these investments have not always achieved what was intended and have even had detrimental effects on the sustainability of both dryland and water management.

Sustainably managing water resources to ensure availability throughout the year is considered by some to be central to unlocking the development potential of dryland areas (Nkonya, E., et al, 2011). However, permanent year-round water supply in some rangelands can be harmful to biodiversity and productivity if it encourages permanent grazing. Similarly, a focus on year-round availability of water can encourage unsustainable groundwater abstraction and inappropriate forms of irrigation that make inefficient use of water, and in many cases lead to land degradation, unsustainable groundwater use, and soil salinization. It is therefore a better understanding of the spatial distribution and timing of water availability in dryland areas that can support improved water management practices in these regions of the world.

Growing grapes on the edge of the Atacama Desert, Chile © James Dalton

Applying an ecosystems approach to Integrated Water Resources Management

Ecosystems are complex and are characterised by unexpected responses to different interventions (Pahl-Wostl et al., 2007). Water flows in dryland ecosystems are often characterized by irregular inputs but regular outputs (Agnew and Anderson, 1992). Based on these water outputs, other ecosystem services can give an indication of the health of a dryland ecosystem. Rangelands are places of important biodiversity and ecosystem services that occupy up to three quarters of the world's drylands. Sustainably managed rangelands deliver important benefits through the ecosystem services they provide, such as improved water cycling and climate regulation, which have knock-on effects on populations locally and externally. Sustainably managed land and water resources can mean improved infiltration of water, reduced surface flow, and greater soil moisture, contributing to vegetation growth and cover, biodiversity, soil fertility and carbon sequestration in the dryland ecosystem itself, while recharging groundwater, increasing water flows downstream, providing safe drinking water, and in some cases reducing siltation of reservoirs can benefit consumers of water and of hydroelectric power (Davies et al, 2015).

There is, however, need to consider not only the rainfall amount and intensity in drylands, but also the suitability of dryland soils to absorb the rain and maintain soil moisture throughout the year. Some dryland soils, such as those of the Sahel, are particularly poor in organic carbon which limits their capacity to absorb and hold water. The seasonality of precipitation in drylands is also an important element in unlocking development in dryland areas. It is important therefore to consider the inherent coping mechanisms of dryland ecosystems with periodic intensive rainfall and droughts for example and to understand how dryland biodiversity and ecology naturally adapts to such situations.

Integrated Water Resource Management (IWRM) is promoted as a mainstream approach to managing water in river basins (Jonch-Clausen and Fugl, 2001). Any approach that aims to maintain and rehabilitate natural regulatory functions of ecosystems for the water cycle within an entire water catchment could be considered an ecosystem approach to IWRM. The ecosystem approach provides a step-wise process to dealing with integration and sustainability of water management. These steps can be related to practical water management issues using the following questions to help frame responses (adapted from Barchiesi et al, 2014), which relate closely to the questions guiding the case studies in this report (see Figure 1):

1. What is the water-related problem?
2. What ecosystem services are impacted and how they can be strengthened?
3. What actions are needed?
4. What benefits can be perceived by different actors?
5. What knowledge and capacities are needed?
6. How can resource rights be guaranteed for local dryland and water users?
7. What governance and what agreements are needed to enable action?
8. What incentives and financing are needed?
9. Who needs to be empowered to act?

Application of an ecosystem approach to IWRM has been tested in many river basins and smaller catchments in different regions and climatic settings around the world. Results have demonstrated the benefits for reducing climate vulnerabilities, conserving biodiversity, and

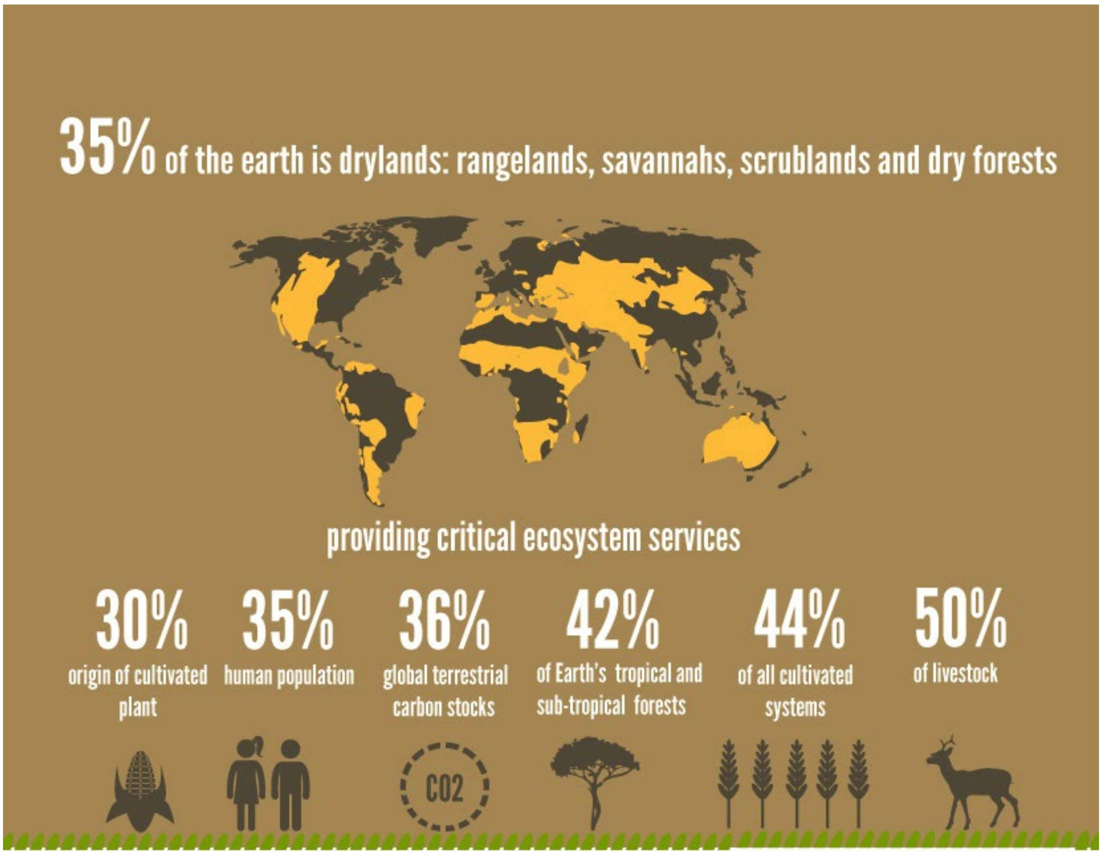


Figure 4 Ecosystem Services from the World's Drylands, UNCCD (2014)

strengthening ecosystem resilience in river basins. For example, the IUCN Water and Nature Initiative (WANI) has worked with over 80 organizations across the world to demonstrate water management that supports healthy rivers and communities (Smith and Cartin, 2011). The lessons from these demonstration projects show that IWRM tools based on an ecosystem approach can also be used in strategies for climate change adaptation (Bergkamp et al., 2003), and biodiversity conservation. The lessons learned in WANI demonstrate that IWRM is practical and achievable (IUCN Water, 2011; Barchiesi et al, 2014) if:

- Ecosystem services are considered as part of the solution to water scarcity;
- Investment decisions support the implementation of an ecosystem approach;
- Financial incentives support sustainable management of freshwater ecosystems;
- Empowerment enables participation in action;
- Building consensus legitimates action by actors;
- Improved water governance underpins action;
- Lack of transboundary coordination does not impair action.

IWRM can provide the framework for an ecosystem approach in the drylands, but its application should be informed by an understanding of dryland ecology, specific adaptations of dryland ecosystems and livelihoods, and the appropriate interventions and institutional arrangements for managing water in the drylands effectively.

Practical strategies associated with IWRM are intended to overcome lack of coordination and disjointed planning among sectors that can otherwise result in unnecessary expenditure. They should also address large infrastructure failing to provide expected results but which impact negatively on natural ecosystems and on other users (Sanchez and Roberts, 2014). For instance, the negative impacts of dams on ecosystems are expected to be more severe for drier regions. Although there may be fewer dams, river flows can be low and highly seasonal and ecosystems are therefore more sensitive to disruption of the annual rhythm of flooding and recession of water (UNEP-DHI & UNEP, 2016).

There are important differences in dryland water development in the areas of water supply points for domestic use, livestock or irrigation, capturing and storage of water in open reservoirs versus underground, and sound management of water and other natural resources. Best practices usually achieve objectives, such as reduced soil erosion, improved soil and water conservation, higher rain-fed agricultural productivity, recharged groundwater for drinking and irrigation, higher productivity of non-arable lands (range and woodlands), benefits skewed toward poorer members of society, employment creation (directly and indirectly), and promotion of collective action (Mtisi and Nicol, 2013). Where conditions of water scarcity prevail, such as in drylands, proposed solutions to water-energy-food nexus challenges have often been driven by a paradigm of control (i.e. an attempt to achieve stability and durability of supply) which has favoured the construction of large infrastructure. Such interventions assume a much higher level of certainty than is actually warranted leaving less room for flexibility which is key in adaptation strategies. Water-energy-food systems are by nature complex and dynamic systems, and even more so in drylands under the conditions of climate change. A shift in governance and management is therefore required away from a control-orientated perspective and towards approaches where complexity and uncertainty (of climate and ecosystems) are accommodated, and limits to control are acknowledged and incorporated: i.e. approaches and solutions that build on and strengthen resilience (Allouche et al., 2014).

North Saharan oasis and village in the Dades Valley, Morocco @ Stefano Barchiesi

Water governance in drylands

Water governance relates to the range of political, social, economic and environmental systems that are controlled by decision-making and put in place to develop and manage water resources and the delivery of water services at different levels of society. Water governance is concerned more with the way decisions are made (i.e. how, by whom, and under what conditions), than about the decisions themselves. It is therefore often expressed in terms of transparency, accountability and information sharing (IUCN ROWA, 2015). Policy and law, when combined with institutions, implementation, and enforcement mechanisms, are an important part of a country's 'water governance capacity' (Iza and Stein, 2009).

In the context of many drylands, especially in Africa and the Middle East, the dilemmas surrounding water-related decisions have to be resolved by means of negotiated community-based agreements that reconcile competing interests. These agreements on the management of shared natural resources are negotiated among local users and national agencies, often (but not necessarily) with support from external agencies (Laban et al, 2005). Agreements, including traditional customary rules, are sometimes formalised, for example through establishing local government by-laws. These agreements may regulate access and use of communal resources such as water points, dry-season pastures, and post-harvest fields (Mortimer et al., 2009). They may also regulate equitable access and use of scarce water resources by different social groups (Moriarty et al., 2007).

By-laws are community-established rules and regulations that guide the management, access and use of shared natural resources, including water. They can bring together indigenous knowledge or traditional governance systems with formal laws and institutions. In such negotiations, mobile pastoralists, being unable to assert their rights by cultivation, may need support through their own institutions to participate on an equal footing. A prior condition of all such consensus-building negotiations is that government should relax its control over natural resources and place its trust in local users' knowledge and institutions (Herrera et al., 2014).

In some remote dryland areas, where traditional governance structures are still functional, there has been less evidence of dryland degradation (Niamir-Fuller, 1999). Integrated ecosystem management approaches to IWRM, as proposed in this study, may however challenge conventional structures of governance as both multi-sectoral and multi-level integrated approaches are required, contradicting the familiar patterns of sectoral administrations and hierarchical authority (Mortimer et al., 2009).

In the Arab countries of the Middle-Eastern region, where the natural environment is predominantly characterized by aridity, fluctuation and uncertainty, cooperation over shared resources becomes essential to securing the livelihoods of local communities. In recent years efforts have been made in West Asia to revive the age-old community-based natural resource management model of *hima* which works on the basis of community participation and reaching consensus through consultation. Hima initiatives have contributed to saving and protecting natural resources, rangelands and forests. Nurturing further "hima" approaches could provide the enabling environment for managing conflicts and constituting a basis for local dryland governance (Haddad, 2014; Al Jayyousi, 2014).

The already high degree of uncertainty and unpredictability in dryland ecosystems becomes even more pronounced with climate change. The speed, severity, and complexity of climate change, and its accelerating relationship with more gradual non-climate stressors on water, present challenges that lie far outside the traditional coping capacity of most traditional water governance and management approaches (Sanchez and Roberts, 2014). This calls for institutional involvement of government and

Small agriculture area in the Todgha Gorge of the High Atlas Mountains, Morocco @ Stefano Barchiesi

other organizations in policy and practice. The UNCCD targets for Land Degradation Neutrality (to be detailed at the country level) could be instrumental to mobilize interest and resources for this, noting that water and dryland management are intrinsically related (IUCN, 2015).

Regions facing increasing drought and water scarcity problems such as drylands could be first mapped, and river basins delineated to establish ecosystem management units. Such identification and delineation would allow adjustment of ecosystem management as well as development projects in these areas to their specific conditions. Identification of such units includes characterization of drought events and water scarcity trends (scale, duration, severity), as well as productive potential for agricultural or rangeland use. Such efforts need to be accompanied by monitoring and short-term forecasting and, from a governance point of view, the processes for developing water resource management plans (that take into account risks of drought and water scarcity trends). These actions should be an essential part of river basin plans and reviewed on a regular basis, in order to account for advances in drought preparedness planning (Xerochore, 2010).

River basin or water catchment institutions can and do have a coordinating function, whereby they provide a focal point for representation in the decision-making across the basin. In particular they need to reconcile different types of data and information from national and local level stakeholders that need to be considered and coordinated at the highest decision making level. Although not dealing explicitly with climate change, a step-wise and cyclical approach to river basin planning and management such as the European Union's Water Framework Directive has enabled adaptive management in the face of climate change and other stressors (Sanchez and Roberts, 2014).

Some of the most common challenges to water resource planning (including risks of drought and water scarcity) are (Xerochore, 2010):

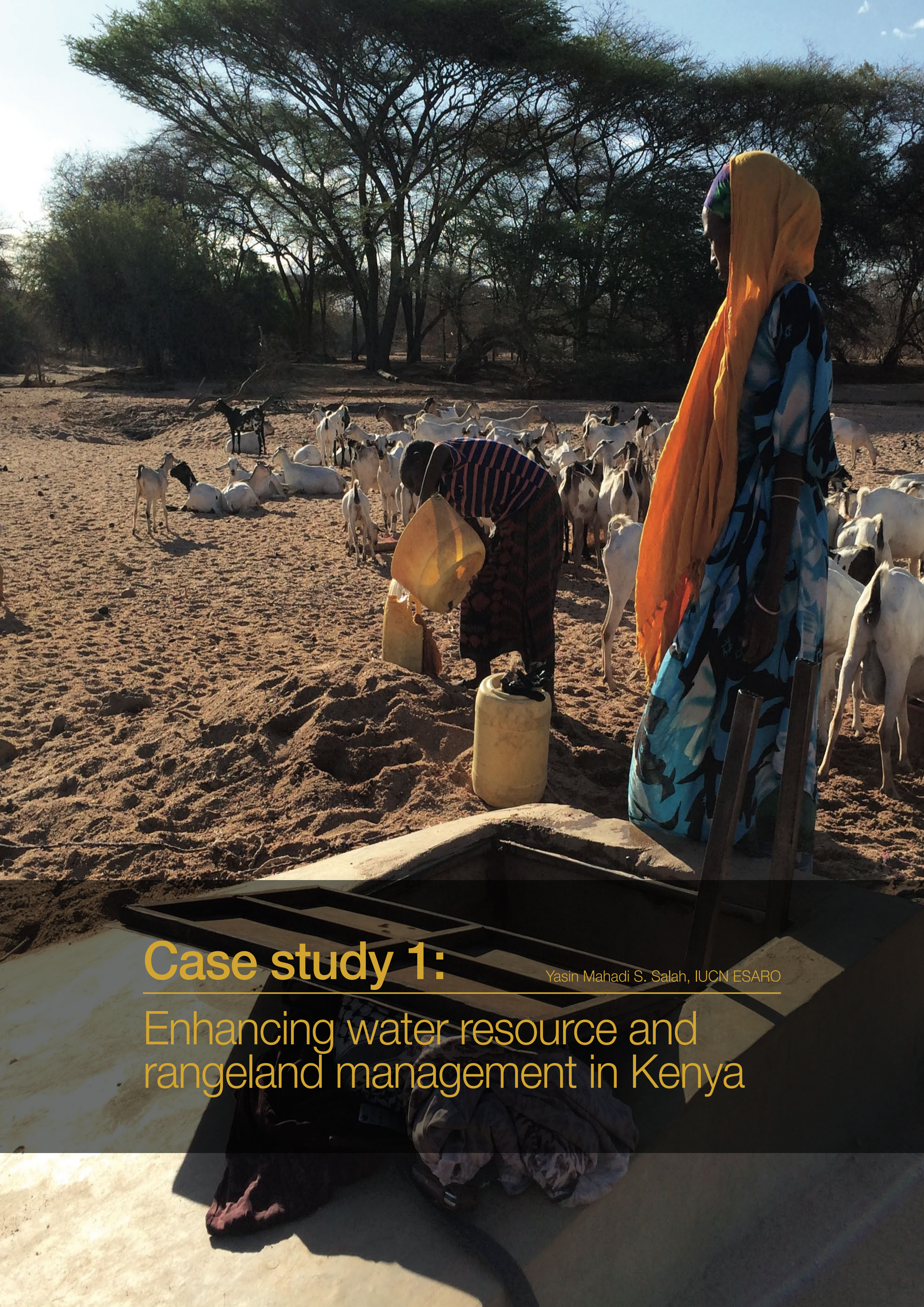
- Existing water management practices (mainly supply-oriented) have proven inefficient to cope with the adverse impacts of drought, leading to overexploitation of water bodies (e.g. rivers and reservoirs). As a result the survival of aquatic ecosystems is jeopardised due to the additional stresses put upon them.

- Water management is often implemented independently of other national policies. For example, there may be no linkage among water management and rural development plans, particularly regarding the agricultural sector. Furthermore, the impacts of these plans on aquatic ecosystems have not been examined during their development (e.g. impacts of drainage systems and constructions on natural vegetation and soil humidity).
- Participatory processes are not included in decision-making for mitigating impacts of water scarcity and drought events. Important topics for the successful implementation of such processes are the use of a common language among stakeholders, including use of comparable indicators, and conflict resolution techniques among water users.

These challenges are even more prominent in dryland ecosystems with their high degree of unpredictability. The IUCN-led project "Social, Ecological and Agricultural Resilience in the Face of Climate Change" (SEARCH: 2011-2013) obtained practical examples on how to plan for climate change impacts including from droughts through learning and piloting practices with the full participation of all the relevant stakeholders in five East and Southern Mediterranean countries (Morocco, Egypt, Lebanon, Palestine and Jordan). For this purpose, SEARCH adopted the EMPOWERS Participatory Water Planning Cycle by modifying the six steps of the management cycle (i.e. visioning, assessing, strategizing, planning, implementing and reflecting) and respective sub-steps (Moriarty et al, 2007; IUCN ROWA, 2014). The aim has been to produce coherent climate change adaptation strategies at local, national, and at basin levels. Use of scenario building has resulted in strategies that take into account and mitigate future uncertainty and risk such as externalities on other sectors outside water. The most robust strategies are those that achieve the vision for the basin under most scenarios, with the basin being the best approximation of an ecosystem scale. Lessons from local level project implementation can now also be incorporated into more strategic planning at broader scales in order to build climate change resilience at the basin or country level.

Tackling the challenges of water governance requires coordinated efforts among policy makers, traditional authorities, government practitioners, environmental groups, and local dryland users, both men and women. Good governance is a means to an end: it can deliver beneficial outcomes for society, the economy and the environment at once. Good governance practices allow responding to the problems of today with policies that are consistent with long-term goals, which for drylands are even more critical. An effective governance system represents appropriate mechanisms for the management of water in a sustainable, integrated and inclusive manner that can help tackle water challenges and make political will effective on the ground (IUCN ROWA, 2015).

Nature-based solutions refer to the sustainable management and use of nature for tackling various societal challenges. In drylands this results in strengthening the resilience of ecosystems to increase infiltration, enhance soil moisture retention and reduce evaporation, whilst at the same time working with local customary interventions to ensure livelihoods are maintained. Based on work by IUCN and its partners, the six case studies described below address the guiding questions posed by this study in a range of different contexts from West and East Africa to West and South Asia to Central America.



Case study 1:

Yasin Mahadi S. Salah, IUCN ESARO

Enhancing water resource and rangeland management in Kenya

The People and Landscapes Programme of the Eastern and Southern Africa Regional Office of IUCN implements a project called *"Water for Livestock in Isiolo and Garissa Counties, Kenya Enhancing water resource and rangeland management, community capacity through training and cash for work program"*.

The main objective of the project is to improve livelihoods and resilience against drought for targeted communities by improving access to water for livestock in ways that promote sustainable management of rangeland resources and strengthen resilience of local communities in times of drought and climate variability. The project links with both national and county level policies and was targeted largely towards fulfilling the country's national priorities of increasing livestock productivity and building resilience to drought of pastoral communities. This project was developed in response to the 2011-12 drought in Northern Kenya.

Poorly sited livestock watering points in rangelands often leads to range degradation and conflicts between different communities that sometimes become violent, especially when droughts emerge. Despite the fact that community participation in development projects is a long-established principle, these water points are often installed without any community consultation, being based on an outside water engineer's perspective of what is technically feasible, rather than a community view on what is socially and ecologically desirable. This is largely caused by the 'emergency mode' of operation stemming from the drought conditions.

As activities in the area moved from 'emergency response' to 'community development' it was possible to introduce other elements. Critically, the project undertook strategic water development based on community needs and in the context of rangeland management planning. The rangeland management plans indicate the traditional movement patterns of pastoral communities in the wet and dry seasons between respective wet and dry season grazing areas. The specific concern that the project addressed was to balance the availability of water with the condition of the rangeland, termed 'water–rangeland balance'. This aimed at increasing livestock access to water so as to extend the wet season grazing period without leading to rangeland degradation. The project was based on the fact that communities are forced to move away from wet season grazing due to decline in availability of water for their livestock despite the abundance of pasture. This meant that they would not adequately utilize the available pasture. Community needs are at the centre of water development in this project and therefore the aim is trying to balance water needs and pasture availability. The main difference between this project and others implemented in the region is that it has undertaken participatory strategic water development based on community needs and rangeland management plans.

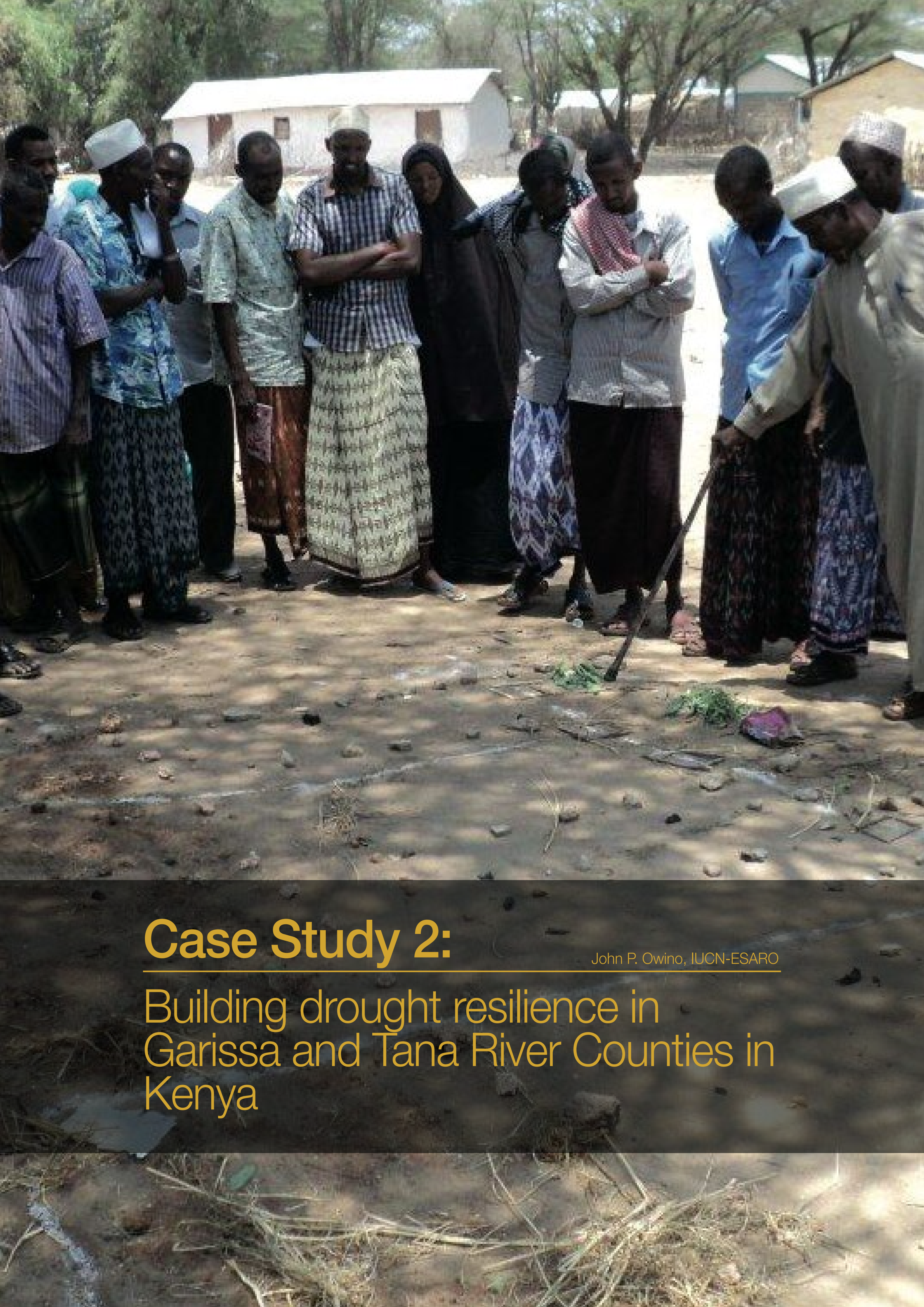
The innovation in the project was to introduce a social feasibility/validation process into the process of developing subsurface dams. This has enabled communities to stay in wet season grazing areas long enough to utilize the available pasture before moving to dry season grazing areas. Sub-surface dams work by increasing the height of a rock sill within a seasonal river by installing a dam, but one that does not reach the surface. Thus the river appears unchanged. The water is accessed by improved shallow wells similar to existing local practice but that improve the water quality and availability. These dams collected water for livestock for an additional 1-2 months. Consultations were carried out with communities and other relevant stakeholders to agree on the location of these water points. Some of the key factors considered in the location of the water points are community livestock movements, proximity to permanent or temporary residential areas, the relevance of these water points to the community needs and conflict sensitivity. There is however a risk that if the wrong infrastructure is put in place, livestock will may stay more permanently in one location, potentially causing over-grazing and soil compaction in one area, and therefore degradation of a potentially fragile part of the ecosystem. This could lead to significant conflicts between communities and pastoralists.

Watering livestock from shallow well in Qur qura, Garba Tula Kenya during drought period © Yasin Mahadi S. Salah

The county government of Isiolo has begun to scale up the approach by budgeting for the development of two further subsurface dams. However, it is still unclear if they will follow the process used by the project in community validation in identifying sites and establishing the infrastructure needed. Mechanisms therefore need to be found for institutionalising the community validation process. One possible way is including these kinds of projects in social and environmental assessment mechanisms.

The project has achieved some positive outcomes due to the modest and low impact nature of the technology being used. The amount of water available at specific sites and how long the communities are using the water in the subsurface dams compared to the period before the subsurface dams has been monitored. Communities are now able to stay in the wet season grazing pastures for one to two months more and, the livestock movement patterns have not been disrupted. There is however still need to further monitor the effects of the approach on long-term rangeland condition. Other gaps that need to be addressed in addition to monitoring are in the management of the subsurface dams. Currently there is open access for everyone to utilize the water in the dams. Measures to manage the water points with influx of other communities into the region need to be planned and managed. Currently the process of developing the subsurface dams is being done at the community level and engagement with the county government is still lacking.

The main lesson from the project is that the 'Water-Pasture balance' is critical for the resilience of rangeland communities; too much water for too long can lead to population increases, permanent settlement, conflict and degradation. There is also a need to understand and build on traditional grazing patterns as managed by traditional institutions and greater importance needs to be given to the governance and ecological considerations of range management.



Case Study 2:

John P. Owino, IUCN-ESARO

Building drought resilience in Garissa and Tana River Counties in Kenya

The IUCN project *Building Drought Resilience (BDR)* is implemented in the Arid and Semi-Arid Lands (ASALs) of Garissa and Tana River counties in Kenya. The main objective of the project is to improve the resilience of dryland communities within a river catchment against the impacts of increasingly severe and frequent drought, through strengthened ecosystem management and adaptive capacity of local communities. Hence, the project was developed taking into account both sustainable water and dryland management.

The project had to adopt an integrated approach in the management of water and pasture. This integrated approach incorporates both the participatory rangeland management planning with that of water sub-catchment management planning. As seen above, in the Water for Livestock project (Case Study #1), integrating the two approaches is useful because drylands are unique areas that require tailored and appropriate planning and management approaches. Key specific aspects of Kenyan drylands include:

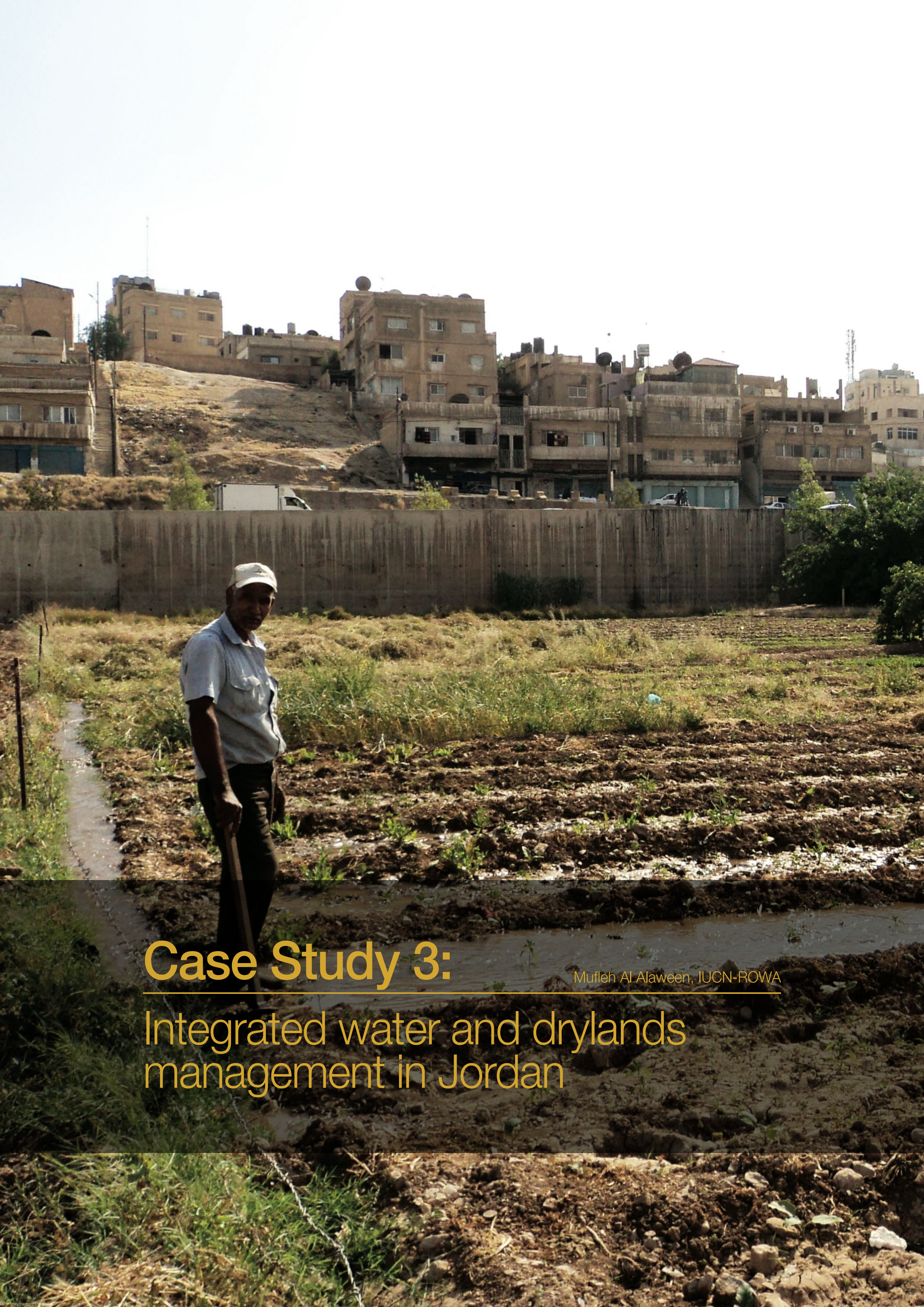
- scarcity of water resources and fragile heterogeneous landscapes that are prone to degradation;
- adverse impacts of climate change in recent decades contributing to higher rainfall variability and lower reliability than in the past;
- communal ownership of land and its use for nomadic pastoralism where mobility is integral to survival;
- increasing constraints to mobility as dry season grazing reserves and pastures areas are converted into farm lands and haphazard settlements;
- the spread of invasive weeds such as *Prosopis juliflora* adversely affecting natural pastures;
- high levels of poverty; strong reliance by communities on natural resources for livelihood options;
- weak governance system for natural resources management resulting in unsustainable use and;
- poor understanding of the dynamics and key elements of dryland systems leading to inappropriate approaches to development e.g. ad hoc provision of water resources.

So far, one of the main impacts from the project has been the identification and demarcation of livestock corridors (traditionally referred to as malkas) in the project areas to avoid conflict between livestock keepers and crop farmers. Malkas are access routes to water points and farmers are now not allowed to cultivate within the corridors. In addition, the project also promoted dry season grazing areas to be used by pastoralists by protecting the river banks. There has also been pasture and rangeland re-vegetation witnessed over a period of time associated with the project.

The project links directly with county and national government policy. Firstly, because the sub-catchment management planning process is a national government process being used by the Water Resources Management Authority (WRMA) as a standard for the whole country, whether in the ASALs or higher rainfall areas. At the same time, some aspects of land-use planning and natural resources management have been decentralized to the county levels. The project therefore aimed to influence WRMA's policy by incorporating dryland specific concerns into this planning process.

WRMA is already testing this integrated approach by scaling it up in other dryland areas. Through such best practices from projects, policies may be influenced in addition to supporting capacity building activities. There is need for the Government of Kenya to adopt the integrated approach and process officially as a framework for the management of water and pasture in dryland areas.

The main lesson learnt from this project is that resource planning in drylands revolves around water and it is around water that the local laws and regulations for access and use of dryland resources are set. Water use and management in these ecosystems consequently has implications on access to vegetation, pastures, crops and other dryland resources.



Case Study 3:

Mufleh Al Alaween, IUCN-ROWA

Integrated water and drylands management in Jordan

Zarqa river, Zarqa governorate, Jordan © Lara Nassar

Jordan is predominantly covered by drylands, with 80% of the country receiving an annual precipitation of about 100mm or less. It has a climate characterized by hot and dry summers with an average temperature of about 30 °C and short and cool winters averaging around 13 °C. The weather is humid from November to March and dry for the rest of the year, with hot, dry summers and cool winters during which practically all of the precipitation occurs. In general, the farther inland from the Mediterranean, the greater are the seasonal contrasts in temperature and the less the rainfall. Potential evaporation is high due to high temperatures in summer. Water demand increases dramatically as the temperature rises with the season, and accordingly illegal water abstractions become more widespread.

Climate change, mismanagement and inherent water scarcity are the main drivers for IWRM projects in Jordan. Most of the interventions of the Water and Climate Change Programme of the West Asia Regional Office of IUCN are formulated to deal with IWRM in dryland situations. The main aim of these projects is to promote water use efficiency for both domestic and agriculture use, improve water governance, and minimize water losses as these can be as high as 45% for drinking water, in order to re-allocate water to nature. Water related projects should also be careful to at least not lead to overgrazing or overuse of available resources in order to avoid or minimize land or ecosystem degradation.

Within Jordan, there are also areas, mainly in the highlands, that are less dry and receive rainfall of about 350mm annually. In these areas, IUCN works with farmers to promote rainwater harvesting which is then used during the summer period for domestic and non-domestic use including livestock and supplementary irrigation for fruit trees. Rain water harvesting in these areas is carried out in two ways: either rain water is harvested and stored at the farm level or it is harvested and stored at the household level through capturing rooftop runoff in storage tanks and underground wells for domestic use. In the first scenario, water is stored within the soil profile. Techniques used on farms are aimed at maintaining soil moisture content through the summer period. Some of the techniques adopted include the use of stone terraces, fallow canals and mulching (i.e. spreading a protective layer of a material on top of the soil).

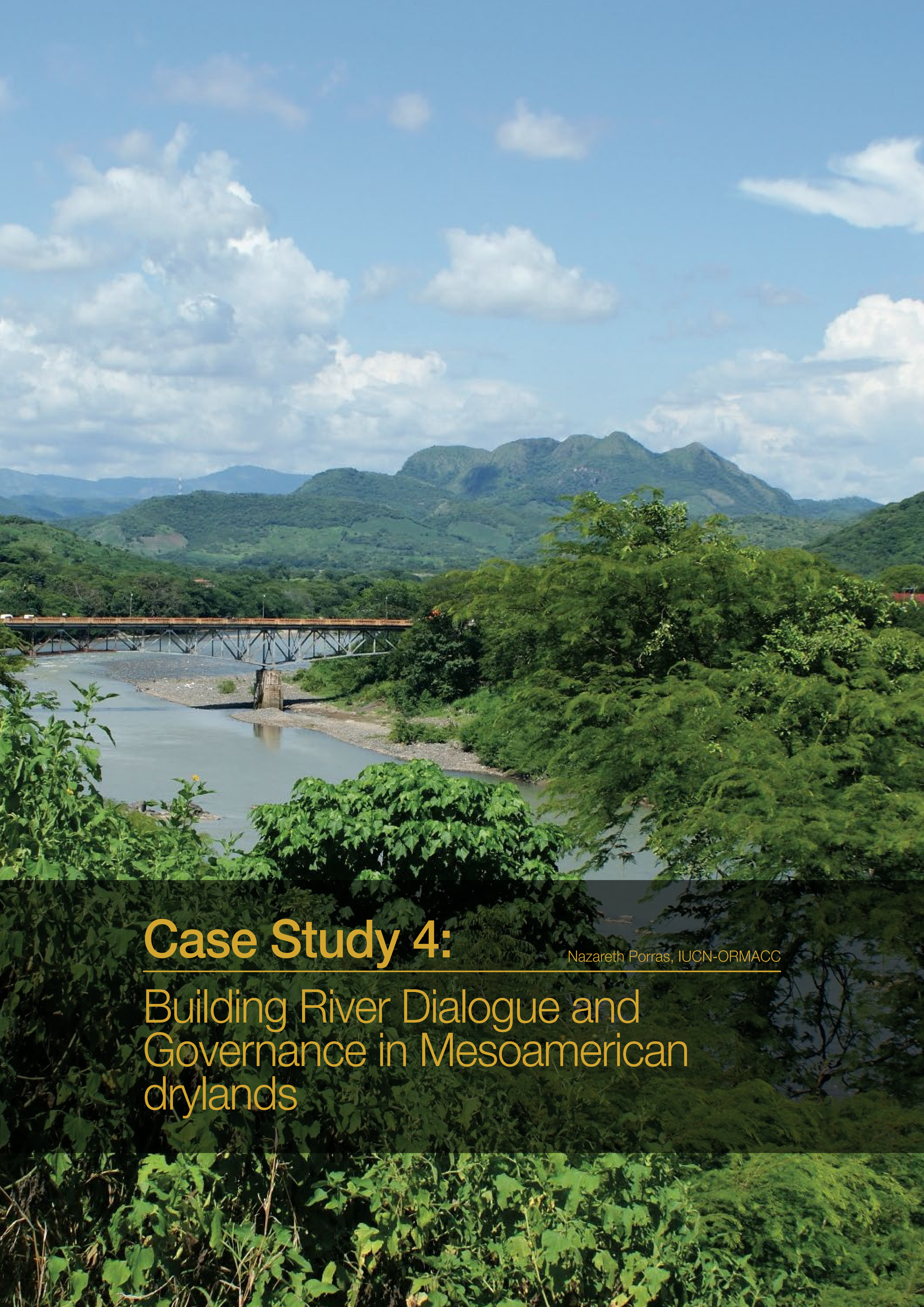
The main positive impact from current water projects is the increase in water use efficiency. In order to manage the impact of drought, however, there is a need for alternative income sources to avoid over reliance on livestock leading to overgrazing of the land cover. Lessons from other IUCN interventions in Jordan have demonstrated the value of integrating rangeland management and restoration in order to protect or restore the hydrological cycle. This is typically carried out through reviving *Hima* systems; the customary practice of protecting rangelands and other natural resources for sustainable use.

A national steering committee is formed at the beginning of any project in Jordan to ensure that the project work links and complies directly with national policy. The national steering committees normally include senior government officials from the Ministries concerned through whom policy recommendations are discussed at the highest levels. Along this vein, the West Asia Regional Office of IUCN in Jordan has participated in the revision and updating of the climate change and drylands strategy of Jordan in compliance with the UNCCD and the UNFCCC.

Despite these achievements there are still gaps in knowledge and policy. Most of these gaps relate to knowledge of all levels of water governance found in the country, knowledge of solutions available for water demand management and how to overcome their implementation challenges, knowledge for water managers to consider water environmental flows (i.e. water for nature) as well as general lack of information sharing, transparency and accountability. This affects ownership and the rights of the end users are also not clearly known to them.

The most important lesson on the effectiveness of the interventions in Jordan is the need for full participation by key stakeholders. Clear and systematic participation of all key stakeholders is key to involving them in dryland management such as through the *Hima* approach. Monitoring of project impact is being carried out by following up on availability of water, crop productivity and diversity of species through comparing the end results with the baseline status. This will ultimately provide stronger lessons.

Ways to filter water for reuse (one part of the process) used for fish tank water © Lara Nassar



Case Study 4:

Nazareth Porras, IUCN-ORMACC

Building River Dialogue and Governance in Mesoamerican drylands

Goascorán upper basin, in Guajiquiro in Honduras © Manuel Farias / IUCN Consultant

The BRIDGE project (Building River Dialogue and Governance) has been working in three transboundary basins in Mesoamerica to promote cooperation and build capacities on water governance of stakeholders at the local, national and transboundary levels. Of the three basins, the Goascorán (shared between Honduras and El Salvador) is the driest, since it is located in the heart of the Central American Dry Corridor. This is a sub-region of the otherwise low water-stress tropical region that extends as a zone with climatic characteristics of a dry tropical forest, with an accentuated and long dry season ("verano"), and where there is a latent risk of recurring droughts during the reduced rainy season ("invierno") caused by a late arrival of the invierno, an extension of the Mid-Summer Drought, or a premature stopping of the invierno" (Peralta Rodríguez et al., 2012).

BRIDGE is working on strengthening governance structures in both countries, aiming at the establishment of binational agreements among stakeholders and therefore binational actions for the sustainable management of the basin. The BRIDGE project in Goascorán was developed with the IWRM approach in mind and the methodology adopted for the three basins is similar, since it focuses on water governance and not on specific field interventions. However, stakeholder priorities vary between the dryland sites and the non-dryland sites.

In this river basin a network of champions, including local officials, has been empowered who can advocate for good water governance and transboundary water management. The network serves as a mechanism for transmitting information and knowledge upwards. As a result of several face-to-face and virtual meetings and exchanges as well as training on IWRM and water governance the network has begun to establish workplans in each sub-catchment. Goascorán champions are also committed to strengthening the once discontinued Goascorán Binational Management Group by implementing local policy advocacy and actively participating in the Group's meetings and activities (MacQuarrie et al., 2013).

Practice has shown that in Goascorán stakeholders are more aware of the effects of the dry, worsening climate while in the other Central American basins the focus is more on broader issues of sustainable development such as tourism, ecosystem conservation, and sustainable agriculture practices among others. Stakeholders in the Goascorán are more worried about food production and the effects of drought due to high rainfall variability which is a main feature of these dryland areas. They are therefore also more concerned about finding solutions to mitigate and adapt to the impacts of climate change on agriculture and the availability of water for human consumption.

The project has had positive impacts on the management of the Goascorán river basin, for example in facilitating the operationalization of the water law in Honduras, through the establishment of basin, sub-basin and micro-watershed councils. Due to synergies with other international cooperation projects, it is working on the development of micro-watershed management plans in order to include climate change adaptation plans that could be linked to broader planning at the basin level.

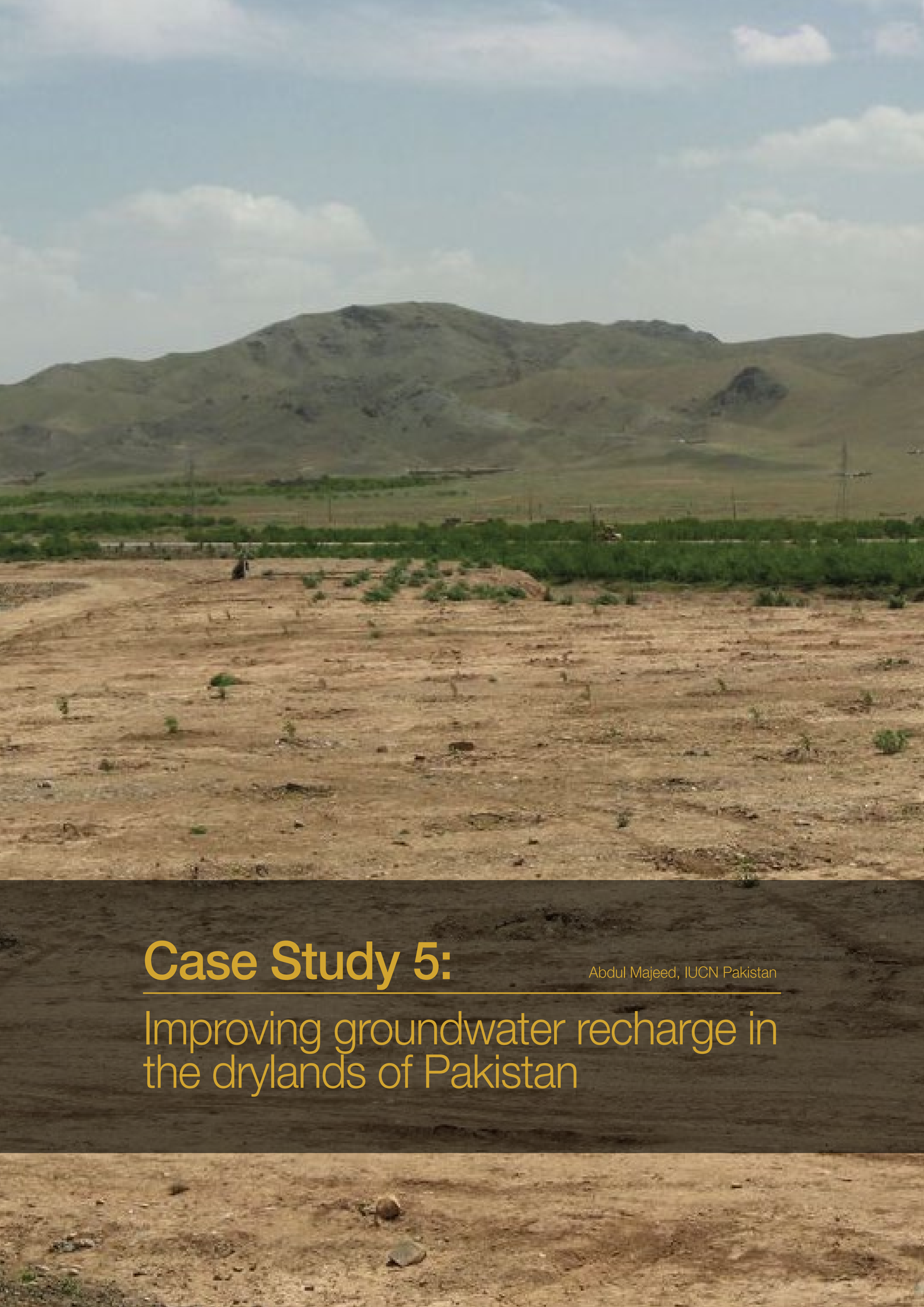
Given the nature of the intervention in Goascorán, there are no direct economic or environmental outcomes to measure in the short term. Social outcomes, however, include strengthening institutional coordination planning for watershed management and participation of local stakeholders in transboundary forums to raise issues of local interest, such as the potential impacts of large dams and transnational highways with the respective national authorities.

Stakeholders in the Goascorán have expressed the need for investment in solutions against the impact of severe droughts in agriculture (aggravated by climate change) such as the introduction of more resistant crops, water harvesting and storage, and livelihood diversification among others. However, communities in this area do not have the resources and knowledge to change current practices and livelihoods to more resilient ones. As a response, the project has enabled the establishment of twelve institutional coordination platforms. The membership of the watershed councils and the binational management group for the Goascorán river basin encompasses government officials, community members and the private sector represented. Local leaders include women representatives.

This project links through local to national policies. At the national level, it is working side by side with the Ministries of the Environment of the two countries. At the local level in Honduras, it is working on implementing the national water policy. The main lesson is therefore on the power of local to national action pathways, whereby locally based stakeholders drive change through innovative thinking, e.g. by working around the absence of binational agreements to implement cooperation across borders at the basin level.

Mayors in Honduras and El Salvador have undertaken joint actions, demonstrating that shared challenges at the basin level - concrete problems that need to be resolved such as the potential impacts of large dams and transnational highways - can mobilise local leaders into becoming trail blazers on transboundary cooperation. This has taught the BRIDGE project team that identifying concrete local issues that will motivate joint action toward cooperative problem solving can provide valuable entry points in future transboundary water governance efforts. Conversely, transboundary structures or platforms on integrated water resources management must bring tangible benefits to stakeholders, such as improvements in sustainable agricultural production or tourism.

Design of the Goascorán basin elaborated by local stakeholders © Manuel Farias / IUCN Consultant



Case Study 5:

Abdul Majeed, IUCN Pakistan

Improving groundwater recharge in the drylands of Pakistan

The recharge mechanism. See the water brought in from dam gushing in the ground through slotted pipe after filtration © Dr. Abdul Majeed

Balochistan is the largest province of Pakistan and is classified as hyper-arid to arid dryland. The annual rainfall over almost 90% of the area varies from less than 50 mm in extremely dry areas to the west and south-west (where Balochistan is) to just over 250 mm in the upland areas in the north and central parts. Agriculture, particularly livestock, provides the main livelihood for the majority of the population. Apple orchards and vineyards are the major agriculture activity with small ruminants constituting the bulk of the livestock. Rampant poverty and poor grazing practices are two of the main factors responsible for degradation of watersheds in the area.

The biggest challenge faced by the province is water scarcity. In the absence of perennial water sources the population has come to rely on groundwater for meeting their domestic and crop water requirements. This has resulted in the groundwater balance being disturbed; there is an increasing gap between abstraction and recharge. Natural recharge in Balochistan has become less effective due to watershed degradation, particularly loss of vegetation and formation of rills and gullies, so that aquifer recharge is reduced and aridity has increased.

In Balochistan, the efforts to recharge the underground aquifers have been practiced through construction of Delay Action Dams (DAD) by the Irrigation Department at huge cost. Water collects behind these dams but is either totally or partially lost to evaporation. It was assumed that ponding the water in the reservoirs created by the dams would help recharge aquifers by simple infiltration. In practice this has not been successful due to siltation of the reservoir beds and sides caused by fine sediments brought in by the feeding streams. This has required interventions not only to artificially recharge the local aquifers but also to promote water conservation in order to recoup the large investment made in these dams.

To address the problems of groundwater depletion and unwise use of water for agriculture and watershed degradation, a pilot demonstration project was undertaken near Balozai Village in Pishin District. The aim of the project was to augment the water received from the reservoir created by the construction of the Balozai dam. As there are no means to release water from the dam for direct use, this is seriously impeding the recharge of Karezes found in the area, which have gone dry. Karezes are gently sloping underground channels used to transport water from an aquifer under a hill. They create a reliable supply of water for human settlements and irrigation in hot, arid, and semi-arid climates (Sarfraz et al., 2012).

As a result of the demonstration project implemented by IUCN, water stored in the reservoir is now being utilized for recharging the land downstream of the dam where a system of Karezes is running that is used for drinking water, agriculture (to irrigate orchards and to grow vegetables) and for domestic needs (drinking, cooking and laundering). There is an expectation that the serious health problems related to water-borne diseases like dysentery, hepatitis and typhoid faced by the community will be ameliorated following increased availability of new, clean water.

Some of the social and environmental impacts of the project include:

- Rise in water table resulting in rejuvenation of local Karezes and enhanced water availability;
- Additional income from fish farming and increased agricultural activity;
- Greening of the local area,
- Better water quality.

A proper measuring system consisting of water meters and water table measurement was installed to help in calculating the water balance. Given the size of the project and the availability of funds, it was not possible to monitor impacts and benefits on the ecosystem. However, students from a local university monitored the impact on the water table.

Despite being a small project, the demonstration had an impact on the Irrigation Department's policy to construct Delay Action Dams with no downstream outlets. After the commissioning of the Project and its outreach to the senior bureaucrats and politicians (the Governor of Balochistan) the department started designing the dams with an outlet on the downstream side to allow water to flow out and spread on the downstream virgin lands for recharge to take place in alternative ways.

Currently there is adequate knowledge to include new and better technologies and practices in water management policies at the national and provincial levels. The problem is enforcement and scaling-up of the policies, which requires political goodwill as well as specific knowledge of ecosystem management in Balochistan. In Pakistan, water is and continues to be the single most important factor in making dryland ecosystems productive to support livelihoods of the inhabitants. Good water management practices can benefit poor people whose livelihoods depend on limited available water resources. The challenge is to work with policy makers to better understand the challenges and to explain to them the effectiveness of good water management practices in drylands so that understanding can improve, investments can be correctly targeted, and wider scale adoption can become a reality.

For dry upland areas of Balochistan, the project sends a clear message that the harvested water stored in existing DADs (now acting as evaporation ponds) can be used for recharging depleted aquifers at low investment cost by using the Karezes technique. What is required is creation of a strong political will among policy makers to not only make use of existing DADs but also construct new dams with leaky structures and/or use this technique as an integral part of the design. The message goes beyond Balochistan as being equally applicable to other dryland areas in the world with similar topography.

Lined water conveyance channel taking water to irrigation fields from the rejuvenated Karez after successful artificial recharge © Salman Ali

Case Study 6:

Claire Pedrot, IUCN-EMP and
Sylvain Zabre, IUCN Burkina Faso

Ecosystems Protecting Infrastructure and Communities in Burkina Faso

Burkina Faso's Sahelian climate is extreme and highly variable and is characterized by a short rainy season from June to October and a long dry season from November to May (González et al., 2011). Prone to strong spatio-temporal variability and irregular rainfall patterns, in some years, deviations in rainfall and the duration of the rainy season of more than 30% have been observed compared to previous years (Hagenlocher, 2013; WB, 2011).

Land degradation is a huge challenge in Burkina Faso. Data from the UNEP-funded Global Assessment of Human-Induced Soil Degradation (GLASOD) classifies around 40% of national territory as having 'very severe' land degradation, rendering Burkina Faso the most affected country in West Africa (FAO, 2007). Globally, desertification costs US$64 billion per annum, or 5% of global agricultural GDP. In Burkina Faso, this phenomenon costs the equivalent of 9% of national agricultural GDP per annum (Jorio, 2013). In addition to land degradation and desertification, a national report identified the erosion of biodiversity, negative climate change impact, and the degradation of water resources as key environmental problems facing Burkina Faso (IMF, 2012).

The pilot project "Ecosystems Protecting Infrastructure and Communities" is addressing issues around drought in Burkina Faso. It is implemented in six villages in the northern region and aims to improve water availability in crop farms, including during dry periods, and recover degraded lands. It also aims to reduce the impacts of climate change such as floods and droughts.

The project targets specific policies on Disaster Risk Reduction, Climate Change and the national programme for food security and rural areas. Building on more than 30 years of experience with soil and water conservation actions, the main project activities include restoration of degraded lands, improving soil fertility and efficient management of water and reforestation. All these actions are in line with national policies on natural resource management. The project supports communities to construct a number of measures to improve the conservation of water and soil, including the following.

- Bunds of stone lines: these are mechanical works composed of stones aligned along the contour lines of the area of land concerned, which reduce water erosion and increase infiltration of water.
- Filtering dykes: these are mechanical constructions consisting of free stones or gabions built across a ravine, which help recover land that is being degraded by gully erosion and recharge groundwater by enhancing infiltration of water into the soil.
- Zaï pits: these are holes of approximately 24cm in diameter, 10-15 cm depth, typically spaced 40 cm apart, and filled with organic manure, which improve water infiltration into the soil, particularly on land which has low porosity.
- Bouli are a type of a pond that collects and stores rainwater and which can recreate an ecosystem favourable to the life of the fauna and the local flora, boosting recharge of water tables during droughts and allowing vegetation to grow even during the dry period.

Practices implemented by this project are mostly locally sourced. Communities were involved in deciding and developing these practices. Vulnerability and capacity assessments were conducted and the communities were able to identify their main hazards and identify local innovations. Each village has a committee of six members bringing together different social groups (including two women). Working in partnership with research institutions, the project has also introduced innovation through the combination of several technologies on the same plot. Some of the research that relates to the technologies adopted for this project includes:

- Use of plants *(Piliostigma reticulatum)* to strengthen bunds;
- Improving Assisted Natural Regeneration (ANR) by preserving some species using Zaï pits;
- Introduction of local species adapted to the area for diverse benefits, including soil protection, shade and soil fertility.

Participation des femmes á la construction. © Zabre Silvain

The project has so far contributed to better management of rainwater in cropped areas, which has in turn improved crop yields and reduced degradation in the project sites. The Zaï pits for instance led to doubling of crop yield in the first year compared to other traditional cropping systems. Based on earlier studies, run off is estimated to have been reduced by about 12% with the construction of stone bunds, and soil loss was equally reduced by 45% (Zougmoré et al., 2003).

With the development of filtering dykes, there has been a significant improvement in yields compared to sites without filtering dikes with estimated values, based on prior research, ranging from 60% to 170% in Northern Burkina Faso (Zougmoré and Zida, 2000; MEE, 2001; Zougmoré *et al.*, 2003). There has also been improved water availability during part of the dry season. The villagers estimate that with adoption of the "bouli" technique and these ponds, they have water for two additional months during the dry season.

Knowledge gaps on dryland management in a context of climate change still exist. There is still a challenge in understanding the complexity for which technologies must evolve. This however requires that appropriate research is initiated in these areas. Construction costs can be high and communities lack the necessary financial support for building micro-dams for storage of rainwater. The lack of local skills to build these structures is also an existing gap. There is also lack of knowledge of good practices in storage and water management. At the political level, the focus is on large rainwater storage structures like dams to the detriment of small dams such as "boulis". However, boulis are much more adapted to the local conditions and solve locally-identified problems. For example, the village of Tibtenga, with 500 inhabitants elected to construct bouli that would be of benefit to their entire community. Scientifically, there are very few studies on "boulis" and their contribution to well-being, particularly local livelihoods.

Among the lessons learnt by the project is that when suitable structures and technologies are put in place in an inclusive manner, results are achieved and felt by all. Technologies developed should also in harmony with the ecosystem and integrated with the community. Accordingly, support to the community for application of these should not only be received in terms of capacity but also materially and financially.

Discussion

Development and management of water resources in drylands is a priority in a number of IUCN interventions. It is key to avoiding or minimizing land degradation as well as restoring degraded lands, and therefore contributes to Land Degradation Neutrality (Davies et al, 2015). The selected case studies show that IUCN and its partners acknowledge the need to do things differently in drylands. However, a number of questions remain regarding how to adapt water management approaches successfully to local natural and social conditions, and how to monitor their effectiveness. The case studies show that lessons learned in one country or context may provide inspiration and direction to interventions elsewhere.

An important ambition of this study has been to stimulate greater exchange of lessons and more collaborative learning. For the purpose of further sharing and dialogue the lessons are grouped as follows:

1. Lessons on integrated management of dryland ecosystems;
2. Lessons on the management of water resources and innovative technologies;
3. Lessons on water governance at different levels;
4. Lessons on monitoring and learning.

Lessons on integrated management of dryland ecosystems

Drylands are characterized by high rates of water loss and great variability in water availability. It is critical to reflect this in the management of water resources. Land management practices can also be modified to maximize rapid water infiltration into the soil. Land productivity is greatly influenced by the capacity of soil to store water and in drylands it is crucially important to manage soil moisture and fertility. Ecosystem management in drylands therefore relates to management of the various steps in the water cycle, starting with land management and the capacity of land to capture and store soil moisture. Moreover, as mentioned earlier, ecosystem services derived from good water management provide the basis for other ecosystem services and for improved livelihoods in general, as for example is illustrated Figure 5 for ecosystem services in the Jordan rangelands.

In most of the case studies, this broad view of ecosystem management—fully integrating land and water management—could have been more strongly emphasized. Some interventions may have a positive impact on water cycling at the ecosystem-scale, but the impact is not explicit in the case studies and has not been closely monitored. In Pakistan for example there is scope to further explore the potential benefits of re-vegetation as a way of improving infiltration and larger scale soil moisture capture. The case study recognizes that loss of vegetation may have reduced infiltration rates. But there is always a balance between loosing soil moisture to transpiration and storing it in the soil for later use. Equally, capturing rapid surface run-off and directing it appropriately, for example for flood irrigation as in Yemen, requires different skills and technologies to wider, more landscape based soil water storage that may benefit livestock grazing.

Similarly in Burkina Faso, the wide-spread up-scaling of water harvesting techniques will inevitably have an impact on overall infiltration of water and there may be scope to capture or at least monitor some of the possible wider ecosystem-level benefits. At the same time it is important to understand potential risks associated with water harvesting, if for example it disrupts surface flows, triggering a cost for water users downstream following decreased water availability. Also, increased water availability may increase crop production in the short-term, but exhaust already low soil fertility and hence lower crop production on the longer term.

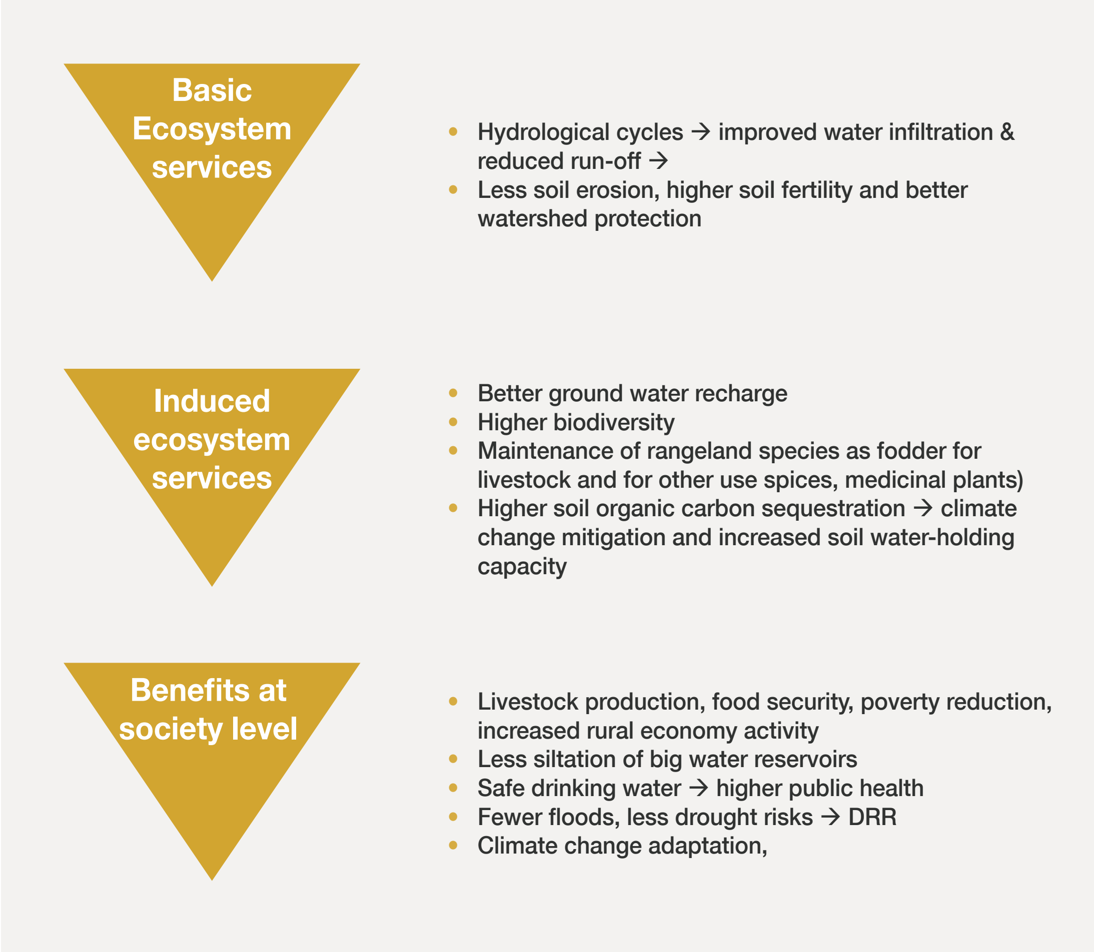


Figure 5 The “value chain” of ecosystem service benefits (Laban et al, 2015)

The Jordan case study demonstrates the scope for modelling the impact of dryland restoration on externalities of water supply. The estimates indicate that improvement of water supply can be the most significant benefit of land restoration in the Baadia. Further work would be valuable to examine whether this is influenced by the comparatively higher value of water in drylands and also to validate the preliminary findings with more empirical evidence from the field.

The work in Isiolo County, Kenya, addresses water management more explicitly at the ecosystem scale. The work examines the role of water supply in determining access to and management of pastures across the landscape. Development of water infrastructure is based on improved understanding of the role that water plays in sustainable land management and an effort was made to monitor the impact on overall rangeland health. In Kenya’s Garissa and Tana River Counties, work has similarly focused on water development as a way to improve efficiency of pasture use at an ecosystem scale. The project focuses on the role of water in mitigating drought risks and supports improved planning of water development that is compatible with landscape-scale rangeland management.

There have been efforts to enhance water governance at the ecosystem scale, most clearly shown in the Honduras-El Salvador case, which could enable better-integrated water management. However, it remains uncertain how well land-use planning is integrated into water governance. If land management practices can have a substantial impact on downstream water availability or quality then it is particularly important to assess this in a cross-border context. Greater learning is needed on how to integrate water management across public sectors in drylands.

When put in practice, an ecosystem approach in drylands often translates into integrated land and water management, which relates to the management of the various steps in the water cycle starting with land management. Realising such practices is challenging due to many conflicting interests and priorities of different public sectors, and due to the transboundary nature of water resources (both domestic and international boundaries). As the Goascorán case illustrates, it is possible to create more integrated institutional arrangements but it requires a significant investment and a high level of political will. Improved inter-sectoral coordination requires, amongst other things, integrated planning at the national level, codes of conduct for joint management of natural resources at the local level, and institutions for transboundary cooperation at both sub-national and inter-national levels.

In summary

An ecosystem approach in drylands usually translates into integrating land and water management and ensuring that the role of land in absorbing, filtering and storing water is fully accounted for. Most of the projects reviewed recognize the need for ecosystem-scale planning of water management but there is a lack of clarity on how to best integrate land and water management at the scale that is relevant in drylands and how to measure the impact of different interventions at the appropriate scale. Monitoring remains difficult, constrained by the scale of potential impacts and the relationship between multiple interventions, and many assumptions are made. Stronger guidance is needed to understand, in particular, land system architecture, the bigger impacts macro-level decisions are likely to have on dryland systems, the externalities such decisions may have, and how countries can adapt to climate change impacts in drylands.

Lessons on water resources management and technologies

Water harvesting technologies are relatively well-known and projects show good awareness of the appropriate solutions in different dryland contexts. As the work from Pakistan shows, efforts are also being made to adapt and innovate approaches in order to resolve challenges around water harvesting and storage using traditional technologies. However, the case study also suggests that long-established interventions can have long-term downstream effects that remain poorly understood, and efforts to improve the established infrastructure must be informed by the consequences of downstream changes in water flow. Small reductions in downstream flows could have profound impacts on a large scale in drylands. For example, reduction in flood plains that restrict grazing zones, or reduction in stream flows that affect downstream populations. Technologies that reduce the total loss of water from the system may be most suitable, but technologies that effectively re-distribute water, or localize it in pans and reservoirs, may in some cases lead to greater overall losses from the system and this may not be desirable. At a minimum such consequences need to be better evaluated with all those who stand to gain and lose from any interventions.

The work in Jordan and Burkina Faso shows strong awareness of the role land plays in storing water, and the importance of trapping rain water in soil. A variety of technologies are used in these cases, particularly in Burkina Faso, although further attention could be given to agro-ecology approaches that promote water conservation through land use management practices rather than implementation of technologies. For example, low-tillage cultivation and agro-forestry may contribute to overall higher soil moisture storage. The Burkina Faso case shows the use of local plant species as a way of strengthening bunds, the use of assisted natural regeneration, and the use of selected tree species for soil protection, shade and soil fertility. However, further understanding as to how land can be managed to increase its water-holding capacity, particularly through increased soil organic carbon is needed. Whilst Zaï pits and other technologies provide this service at small scale, a more explicit analysis could help identify good sustainable, long-term practices in improving soil water-holding capacity at larger scales. The aim of the work in Burkina Faso is explicitly to improve water availability in crop farms, particularly in dry periods, and to recover degraded lands. Yet consideration of downstream impacts, both positive and negative need to be explored with a broader emphasis on wider ecosystem management approaches.

In summary

Technologies tend to be applied to deal with the symptoms of run off and reduced infiltration rather than to address the root problems, for example by improving infiltration rates and soil moisture capacity. Greater consideration should be given to addressing these underlying challenges through use of different technologies or approaches. For example, infiltration rates can be improved by maintaining appropriate vegetation cover, while soil moisture can be maintained through appropriate soil carbon management. Interventions also need scale change. Interventions at small dis-connected 'upstream' locations may affect water flows 'downstream'. Intervention strategies need to be developed with this in mind.

Lessons on water governance at different levels

Governance refers to the process by which decisions are made and it can be strengthened at a number of levels, including at local level where a small group of individuals may be responsible for water or other natural resources, up to district, national and international level. Governance challenges are addressed in most of the case studies, albeit at very different scales. For example, in Burkina Faso governance at the village scale is strengthened through support for women to engage meaningfully in project decision making.

In Kenya the emphasis is on decision making at a higher scale which is determined by the scale of rangeland ecosystems. Community participation and dialogue with local government are the key tools to ensure that decision-making is based on local institutions and knowledge and is channelled up into public planning in devolved government structures. The Kenyan approach in part builds on existing customary institutions and also channels local decision making up into planning at the national level through a Water Resource Management Association, which is exploring how to scale the approach up to the rest of the country. Jordan also places emphasis on participatory decision-making in land restoration but has identified significant knowledge gaps for ensuring that decision-making is adequately informed, for example on ecosystem health or the cost of different externalities. At an institutional level there is often insufficient understanding of how water managers can consider downstream water flows when the conventional focus in drylands has been to store water and restrict flows.

The case study from Honduras and El Salvador revolves around water governance at the transboundary level through establishment of transboundary agreements and implementation of binational actions. The project has facilitated operationalization of the water law in Honduras through the establishment of basin, sub-basin and micro-watershed councils, as well as development of micro-watershed management plans that can be linked to broader planning at the basin level. Through these councils communities have been able to determine investment priorities and institutional coordination has been strengthened, which has in turn contributed to empowerment of local stakeholders and stronger partnership with national authorities.

The case studies have hinted at the tangible and non-tangible benefits of improved water management in dryland ecosystems but in future more detailed assessment could be used to strengthen understanding and valuation of multiple ecosystem services. Deeper insight is needed on the relationship between development interventions in the water sector and wider tenure of natural resources in dryland ecosystems. Future studies need to consider scaling interventions to deliver wider and more sustainable impacts, including community and institutional empowerment, local ownership, and importantly valuation of the ecosystem services and the wider system interactions they support and create. Greater insights are also needed into the downstream implications of water development in the drylands in order to mitigate potential conflicts, including potential transboundary disputes.

In summary

One unique strength of IUCN's approach to water management is the approach to governance at different levels, from community to basin, national and transboundary scales. Greater attention could be given to expanding consultation of different stakeholders, ensuring stakeholder consultations take place at an adequate scale, building capacities and knowledge for more informed decision-making, and enhancing ownership and resource rights for local land users, while adapting and strengthening traditional water/land management institutions.

Lessons on monitoring and learning

Considering the paramount importance of water management in dryland ecosystems, monitoring the impact of land and water interventions on overall water balances is crucial. However, monitoring and evaluation of water-related interventions is an acknowledged weakness in most of the case studies. Some assessment is made of crop productivity as a proxy indicator, but this is insufficient to get a full understanding of improved water management. Other indicators, such as soil moisture or groundwater recharge rates would be valuable but would need to be cost effective.

A particular concern is the lack of monitoring of externalities and downstream impacts and an overall understanding of how localized interventions impact on water availability throughout the ecosystem. This includes an understanding of how water infrastructure influences demographic pressure and immigration. Modelling from Jordan gives an insight into the potentially high value of sustainable land management for water supply to downstream users. Measurement of the impact of land management on infiltration or aquifer recharge is largely absent and this would be a high priority area to rectify. This highlights an important information gap in many project interventions that can be addressed through better intervention design, actively learning from previous work of IUCN and others, appropriate investment in baselines and correct indicator identification, and the use of citizen science capacities and networks. This will require more investment by projects and programmes to help monitor and verify impacts, including using better economic valuation methods and approaches, but it is this information that is more likely to lead to policy review discussions.

In summary

There is a need for improved monitoring of relevant indicators to evaluate the ecosystem-level impact of interventions and to improve understanding of the relationship between land management, restoration activities, agriculture and food security, soil structure and management, and water demand, availability, and supply.

Conclusion and Recommendations

Water scarcity is a global challenge but in dryland solutions must be adapted to the specific conditions of high rainfall variability coupled with high rates of evaporation. Scarcity of water in the drylands means that the relative value of water may be higher, and hence the consequences of changing water flows and disrupting down-stream water availability may be more significant. However, dryland ecosystems are well-adapted to their climatic constraints and can offer useful lessons for improving the efficiency of water management and development through using the value of the natural ecosystem response within wider water management strategies. Using nature based solutions helps to protect the environment as the underlying provider of numerous social and economic benefits. This approach builds upon ecosystem based adaptation and mitigation strategies, and green, natural and built infrastructure solutions (UNEP, 2014).

Land and water resources should be managed together to sustain or enhance productivity of the land to achieve better water management in the entire ecosystem. This is important in drylands because of the high rainfall variability both in space and time and the high rates of evaporation. Solutions for drylands should therefore consider the role and importantly scale of ecosystems in capturing, storing and supplying water efficiently, and should be informed by a suitable analysis of the externalities that may affect these roles. Such analysis should also consider the often high economic and ecological interactions of wetlands within dryland ecosystems and the adequate management of these wetlands.

Nature-based solutions can be instrumental in tackling the challenges and peculiarities of dryland ecosystems. For example, traditional farming practices like Zaï pits in Burkina Faso help to increase infiltration of water and increase soil organic carbon, and hence soil moisture. Rangeland restoration in Jordan slows down surface flows and enhances infiltration, providing better aquifer recharge and a steadier supply of water downstream. Subsurface dams in Kenya and Karezes in Pakistan store water underground where evaporation is minimized.

In many cases adapting water management to dryland ecosystems requires a re-assessment of current land-use practices and how water-cycle management is managed across different sectors and industries active in the area. This in turn will require improvements in knowledge and evidence and more cross-sectoral monitoring systems as well as innovative mechanisms and practices for coordination. Implementation of such new thinking will require institutional and policy changes, and probably paradigm shifts among practitioners and decision-makers, to ensure sustainability and wide-spread adoption.

IUCN’s work shows a number of innovative approaches to strengthening institutional arrangements and governance for better coordination between sectors and between government and society. This includes transboundary institutions in Honduras and El Salvador, national institutional arrangements in Jordan, and local arrangements in Kenya. The Kenyan examples show how community-based planning enables local knowledge, which does not restrict itself to sectoral thinking, can be used to inform sectoral interventions of government. This should lead to better selection of sites and technologies for water infrastructure, and initiate steps to scale this to an impact level beyond communities one at a time.

Specific recommendations, to all components of IUCN and partners, for improving water-related interventions in dryland ecosystems can be clustered into the following areas related to the ecosystem approach and mobilising nature based solutions, rights and governance, and institutional arrangements, including the relevance of our work to support achieving the Sustainable Development Goals.

Utilise ecosystem approaches as nature based solutions for managing water in drylands

1. Actively learn from global experience to practically manage water in drylands in different contexts and scales, including living landscapes. Focus on maximizing soil moisture, increasing infiltration, and minimizing evaporation at wide scale level to support a greater range of benefits, some of which are only evident at larger scales.
2. Develop improved methods for assessing both nature- and technology-based water interventions in drylands to ensure adequate accounting of all costs and performance, for example differentiating between approaches that reduce total water loss from the system and technologies that redistribute water within the system.
3. Pay attention to ecosystem connectivity for people and livestock needs, biodiversity needs and conservation, and hydrological needs and supporting services, such as groundwater recharge as a continuum of a connected surface and sub-surface ecosystem.

Strengthen rights and governance for dryland water resources and land

4. Uphold resource rights, water sharing modalities and local institutions in dryland landscapes by supporting negotiation at the appropriate scale and across scales, recognising that small water resources may support dryland management on a vast scale. The relatively higher transaction costs of negotiating water allocations more inclusively can be offset by much more equal outcomes.
5. Pay more explicit attention to the role that water development can play in resource competition and conflict between crop farmers and pastoralists, recognising that water often determines access to, or use of, land in drylands and that changes in water access can contribute to changes in land ownership and land use.
6. Ensure local ownership and sustainability of water interventions, and more responsive policy and investments by emphasising empowerment of dryland communities, adopting participatory approaches, and generating respect for local and indigenous knowledge, institutions, and behaviours over water resources (e.g. sharing and reciprocity), including seasonal dimensions of access and use rights.
7. Evaluate how water interventions are likely to impact on resource rights and responsibilities, recognising the current realities of drylands, where customary institutions may be strong but State institutions can be weak, human capabilities are often low, and populations are often politically marginalised and may be transient (e.g. pastoralists).

Establish effective institutional arrangements for integrated responses

8. Work with government and non-governmental institutions to integrate water and dryland management across sectors, scales and boundaries (domestic and international), according to each country's specific context, and to ensure that localised water resources (e.g. oases, riparian zones etc.) are not inappropriately removed or captured from the wider hydro-ecological system that depends on them.

9. Strengthen monitoring at the appropriate scale for informed policy and planning of water interventions in drylands: map stakeholders, institutions and ecosystems; monitor environmental, economic and social outcomes (including governance); track tangible and non-tangible benefits and negative or positive effects down-stream.
10. Drylands represent 44% of the global cultivated area. With agriculture as the dominant water user globally, working on improving water management in agriculture could make large improvements to food security and protection of important ecosystem services for our food and livestock systems.

Sustainable Development Goal Targets make clear the need:

- to double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs (**target 2.3**);
- to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality (**target 2.4**);
- to implement integrated water resources management at all levels, including through transboundary cooperation (**target 6.5**);
- to protect and restore water-related ecosystems (**target 6.6**); and,
- to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world by 2030 (**target 15.3**).

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