Natural capital endowment and dynamics of the changing climate in arid and semi-arid lands: experiences from Africa and Asia

Working paper

HEKIMA NI UHURU

PRISE

Pathways to resilience in semi-arid economies

Research for climate–resilient futures

Natural capital endowment and dynamics of the changing climate in arid and semi-arid lands (ASALs): experiences from Africa and Asia

December 2015

Lead author:

Edmund Mabhuye

Contributing authors:

Pius Yanda

Faustin Maganga

Emma Liwenga

Adolphine Kateka

Abdallah Henku

Nico Malik

Cynthia Bavo

This Thematic Review has been produced as part of a series of preliminary papers to guide the long-term research agenda of the Pathways to Resilience in Semi-arid Economies (PRISE) project. PRISE is a five-year, multi-country research project that generates new knowledge about how economic development in semi-arid regions can be made more equitable and resilient to climate change.

Front cover image:
Lady carrying hay.

Acknowledgements

We would like to extend our sincere gratitude to everyone who contributed to the development of this report. We also appreciate comments and contributions received from the internal and external reviewers.

Contents

Tables and figures

Acronyms

ASALs	Arid and Semi-Arid Lands
CBFM	Community-Based Forest Management
CBNRM	Community-Based Natural Resources Management
DFID	Department For International Development
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GoP	Government of Pakistan
IPCC	Intergovernmental Panel on Climate Change
IRS	Indus River System
KPK	Khyber Pakhtunkhwa Province
MEA	Millennium Ecosystem Assessment
MECV	Ministère de l'Environnement et du Cadre de la Vie (Ministry of Environment and Livelihoods)
NAMA	Nationally Appropriate Mitigation Actions
OECD	Organisation for Economic Co-operation and Development
PARC	Pakistan Agricultural Research Council
P/PET	Precipitation to Potential Evapo-Transpiration
PASEF	Projet d'Amélioration et de Valorisation des Services des Ecosystèmes Forestiers au Sénégal (Project for the Improvement and Valuation of Forest Ecosystem Services)
PES	Payment for Ecosystem Services
PRISE	Pathways for Resilience in Semi-arid Economies
REDD	Reduced Emissions from Deforestation and Forest Degradation
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic Commission for Asia and the Pacific
UNEP	United Nations Environment Programme
US	United States
USAID	United States Agency for International Development
WMA	Wildlife Management Areas

Abstract

This natural capital thematic review seeks to generate new information and highlight essential issues for the implementation of the Pathways to Resilience in Semi-arid Economies (PRISE) project. The review analyses the endowment framework underlying natural resource management and drivers of natural resource degradation, including natural processes and calamities induced by climate change. Additionally, it assesses policy frameworks that embed human action in the degradation and management of natural resources in arid and semi-arid lands (ASALs). The review further attempts to unlock natural capital endowments at the global level and zooms in on East Africa, West Africa and Central Asia as case studies.

The reviewed literature includes academic and official reports and online databases (research papers, journal articles and donor reports). The review generates knowledge on key drivers underlying natural resource degradation, livelihood systems and climate change impacts.

The review also provides explanations on the synergistic relationship between natural resource endowment and development patterns in semi-arid areas. It presents the patterns of development and the constraints underlying the attainment of sustainable natural resource management. Finally, it poses key questions that should be considered for further research in the PRISE project. The following points are emphasised:

- It is necessary to have an understanding of patterns found in ecosystem services, distribution, tenure rights and gender-biased access to ecosystem services and natural resources. This also entails a better understanding of the relationship between equity and access to and utilisation of ecosystem services, and how the two can contribute to the alleviation of poverty. The following points are further emphasised:
    - Analysis of the importance of ecosystems in the diversification of livelihoods, associated dynamics and the nature of responses;
    - Generation of knowledge on how issues of tenure, especially as an incentive for natural resource management, and Payment for Ecosystem Services (PES) in order to inform policy for local-level adaptation projects.
- There is a need to analyse how existing policies can strike a balance between attaining sustainable natural resource management and supporting community livelihoods, including nomadic pastoralism. Another important issue to address here could relate to how government can integrate traditional knowledge systems and institutions as viable and sustainable alternative approaches in sustainable natural resource management and in the improvement of livelihood systems in semi-arid ecosystems.
- It is important to analyse the effectiveness of pastoralism in managing resources in harsh and unpredictable environments (Nori et al., 2008). It is also vital to analyse how pastoralism can contribute to debates on climate change adaptation; Tanzanian government policies do not currently address this.

Happy woman farmer*

*photo has been adjusted for print

1. Introduction

Natural capital is the backbone of socioeconomic development and a source of livelihood for communities around the world, including those living in the arid and semi-arid lands (ASALs) of Africa and Asia. It provides a foundation in the form of physical and biological resources for key economic sectors in ASALs, such as agriculture, livestock, water, wildlife, mining and forests. These resources are reflected through renewable natural capital (living species and ecosystems); non-renewable natural capital (subsoil assets such as petroleum, coal and diamonds); replenishable natural capital (the atmosphere, potable water, fertile soils, etc.); and cultivated natural capital (crops, forest plantations, etc.) (Aronson et al., 2007; Ehrlich et al., 2012).

Unfortunately, given the fragile nature of ecosystems in ASALs, these natural resources are undergoing degradation (MEA, 2005a). To a great extent, pollution, land-use change and over-exploitation of biodiversity are causing the degradation; however, population growth, inadequate awareness of environmental conservation and uninformed decision-making also play a role in enabling the degradation process (UNEP, 2009:12-14).[1]

Besides human agency in natural resource degradation, structural factors, such as the inability of institutional, legal and policy frameworks to effectively balance exploitation with conservation and to match national development objectives with the livelihood needs of the poor, have accelerated the degradation of ecosystems and landscapes that underlie the natural capital needed for socioeconomic development (Morton, 2007). Further exacerbating the degradation of natural resources is the changing climate, which is accelerating the fragility of natural ecosystems and landscapes in different parts of the world, including ASALs.

These trends have resulted in massive natural resource degradation and the extinction of species. According to the UN Food and Agriculture Organization (FAO) (2010), the loss of species is 100 to 1,000 times faster than the natural rate. Additionally, FAO estimates that more than 75% of the world's natural resources have been degraded or mismanaged since 1990.

Consequently, various efforts are being undertaken to understand the complex relationship between natural resource management and community resilience in the context of climate change. Pathways to Resilience in Semi-arid Economies (PRISE) is one such initiative.

PRISE is a cross-regional and cross-country project that aims at identifying knowledge gaps and informing policy. The project has five thematic research areas: Climate Risk; Governance, Institutions and Finance; Markets; Human Capital; and Natural Capital. Under the natural capital thematic area, the project seeks to investigate key transmission mechanisms linking natural resource depletion and degradation with impacts on economic growth and poverty reduction, including the valuation of important ecosystem services.

The project also seeks to screen natural resource management policies, processes and institutions and their appropriateness under climate change. Additionally, it seeks to examine allocation decisions facing resource managers, and to work with them to analyse options, articulate trade-offs and identify possible multiple-win strategies. Lastly, the project seeks to evaluate natural resource access and use in the livelihoods and adaptation potential of women and other marginalised groups, review the effect of past and current natural resource governance arrangements on the vulnerability of these groups and identify options to strengthen their natural resource rights.

In line with these PRISE objectives, the natural capital thematic review seeks to analyse the following:

- Natural resource endowment in ASALs;
- Frameworks underlying natural resource management and drivers of natural resource degradation, including the natural processes;
- Calamities induced by climate change and their implications for natural resource management in ASALs;
- Policy frameworks that embed human actions on the degradation and management of natural resources in ASALs;
- The nexus between human processes (e.g. poverty and human interdependence on natural capital) and other key drivers of natural resource degradation.[2]

[1] While acknowledging the contribution of these drivers of natural capital degradation, it is important also to take note of the limitations of analyses that are based on the Malthusian-inspired 'eco-scarcity' paradigm, which rejects perspectives accommodating human agency in dealing with social and physical environment. For a contrast of the two perspectives, see Homer-Dixon (1991, 1994) and Robbins (2004).

[2] As Blaikie and Brookfield (1987) note, the concept 'resource degradation' is *perceptual*.

Depending on the analyst, it may cover various aspects, including loss of productivity, loss of biodiversity, loss of usefulness, loss of resilience, irreversible change or loss of economic productivity. For a discussion of the various aspects of resource degradation, see Abel and Blaikie (1990), Tiffen et al. (1994) and Toulmin (1994).

It also analyses Payment for Ecosystem Services (PES) as an alternative incentive for natural resource management as well as an adaptation option. Additionally, it looks at policy issues in relation to natural capital management, and highlights key questions that need to be addressed.

The barren landscape of Kulaley Village

2. The global perspectives of ASALs

2.1 Global classification and biophysical characteristics

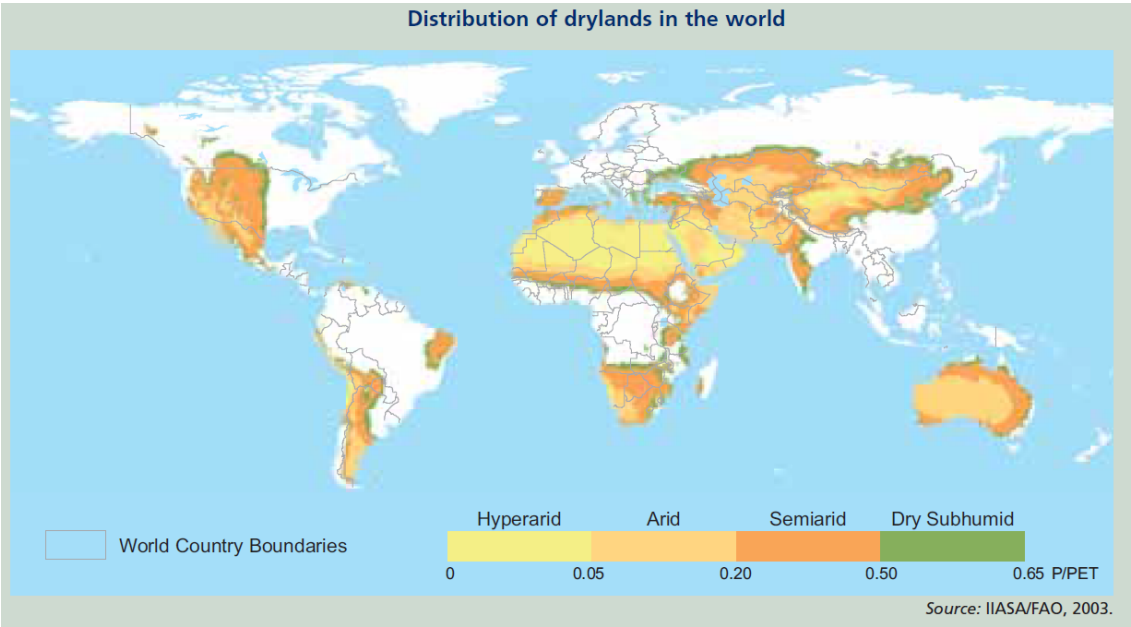
There is no universally agreed on definition for ASALs (FAO, 2010). Consequently, there have been mixed approaches in defining them, with a majority of the literature basing their definition on climatic characterisation (Fabricius et al., 2008). For instance the UK Department for International Development (DFID), as cited by Mongi et al. (2010), defines semi-arid areas as areas where the annual rainfall regime is between 500 and 800 mm. On the other hand, Fabricius et al. (2008) conceptualise aridity as encompassing both arid and semi-arid conditions.

Despite the many given definitions, there are some widely accepted definitions such as those of FAO and the UN Convention to Combat Desertification (UNCCD). FAO (2000) defines ASALs as those areas with a length of growing period of 1 to 179 days; this includes regions climatically classified as arid, semi-arid and dry sub-humid. On the other hand, UNCCD's definition is centred on a ratio of annual precipitation to potential evapo-transpiration (P/PET) (FAO, 2010). Under this definition, the P/PET value indicates the maximum quantity of water capable of being lost as water vapour by a continuous stretch of vegetation in a given climate. Thus, it includes evaporation from the soil and transpiration from the vegetation in a specific region during a given time interval (FAO, 2010).

Under UNCCD classification, drylands are characterised by a P/PET between 0.05 and 0.65; high variability in both rainfall amounts and intensities, of up to 700 mm per annum; periodic droughts; and different associations of vegetative cover and soils (FAO, 2010).

Similarly, Bizikova (2012) defines ASALs according to the sub-categories of aridity (based on the aridity index) and their associated land uses. The sub-categories Bizkova discusses include hyper-arid, arid, semi-arid and sub-humid areas, which are characterised by a P/PET of <0.05, 0.05-0.20, 0.20-0.50, 0.50-0.65, respectively. Based on the Environment Management Group of the UN (2011) classification, hyper-arid areas take up a relatively small percentage of the global land surface area in comparison with arid and semi-arid areas. In agreement with this, Bizikova (2012) estimates that hyper-arid areas occupy 6.6% of the global land surface area, followed by sub-humid areas at 8.7%, then arid areas at 10.6% and lastly semi-arid areas at 15.2%. Figure 1 shows the UN Development Programme (UNDP) attempt, as cited by FAO (2010), to illustrate the classification and distribution of ASALs in the world based on the aridity index.

Figure 1: Distribution of ASALs in the world (classified by aridity index)



Source: FAO (2010).

Despite the mixed approaches in the definition and categorisation of arid and semi-arid areas, ASALs are generally regarded as areas that receive relatively low amounts of precipitation in the form of rainfall or snow (Environment Management Group of the UN, 2011). They are also characterised by high evapo-transpiration, evaporation and runoff. According to FAO (2010), about 90% of the rainfall in ASALs evaporates back into the atmosphere. Evapo-transpiration is estimated at 15% to 25% of precipitation.

Another characteristic of ASALs is the relatively limited recharge of groundwater resources. According to FAO (2010), groundwater recharge in dryland regions is generally more variable and less reliable than in more humid regions. In the few ASALs where the variability of groundwater recharge is relatively low, the rate at which the groundwater is used exceeds the rate at which it is recharged. Moreover, groundwater is susceptible to salinity and mineralisation (ibid.). In spite of this, ASALs are not at a total disadvantage. According to FAO (2010), ASALs have the advantage of having large rivers that originate in areas of higher elevation that can support irrigated farming activities.

Additionally, most ASALs are very windy, owing to the scarcity of vegetation that can reduce air movement. However, vegetation cover does vary among the different sub-categories of ASALs. For instance, vegetation in arid ecosystems largely comprises annual grasslands, which are mainly suitable for grazing animals except where interrupted by rivers or lakes. On the other hand, semi-arid ecosystems are characterised by thorny savannahs with annual and perennial grass species, which are often cleared for farming and livestock and carry the highest human and livestock population densities of the drylands (Environment Management Group of the UN, 2011).

In contrast with arid and semi-arid ecosystems, in sub-humid ecosystems the vegetation cover consists of broad-leaved savannah woodlands with higher, denser tree canopies and perennial grasses (Environment Management Group of the UN, 2011). According to Safriel and Adeel (2005), this forest and woodland system makes up 18% of ASALs. However, the probability of encountering forests in drylands decreases with aridity, hence most of the forest and woodland systems in ASALs prevail along the coast (ibid.).

The characteristics of forest and woodland systems in ASALs also vary. For example, in the ASALs of Africa, forests are very scattered in dry sub-humid areas and rare in the semi-arid zone. In Asia, specifically in countries like China and India, forests penetrate deep into dry sub-humid areas (Safriel and Adeel, 2005). In Europe, where non-drylands surround many dry sub-humid areas, forests are scattered all over dryland areas. In the Americas, forests are patchily distributed in dry sub-humid and semi-arid regions (ibid.).

2.2 Global geographical context of ASALs

Globally, ASALs are found on all continents. According to Bizikova (2012), drylands take up about 40% of the globe's landmass. This is supported by FAO (2010), which also illustrates that drylands cover 40% of the globe's landmass (see Table 1).

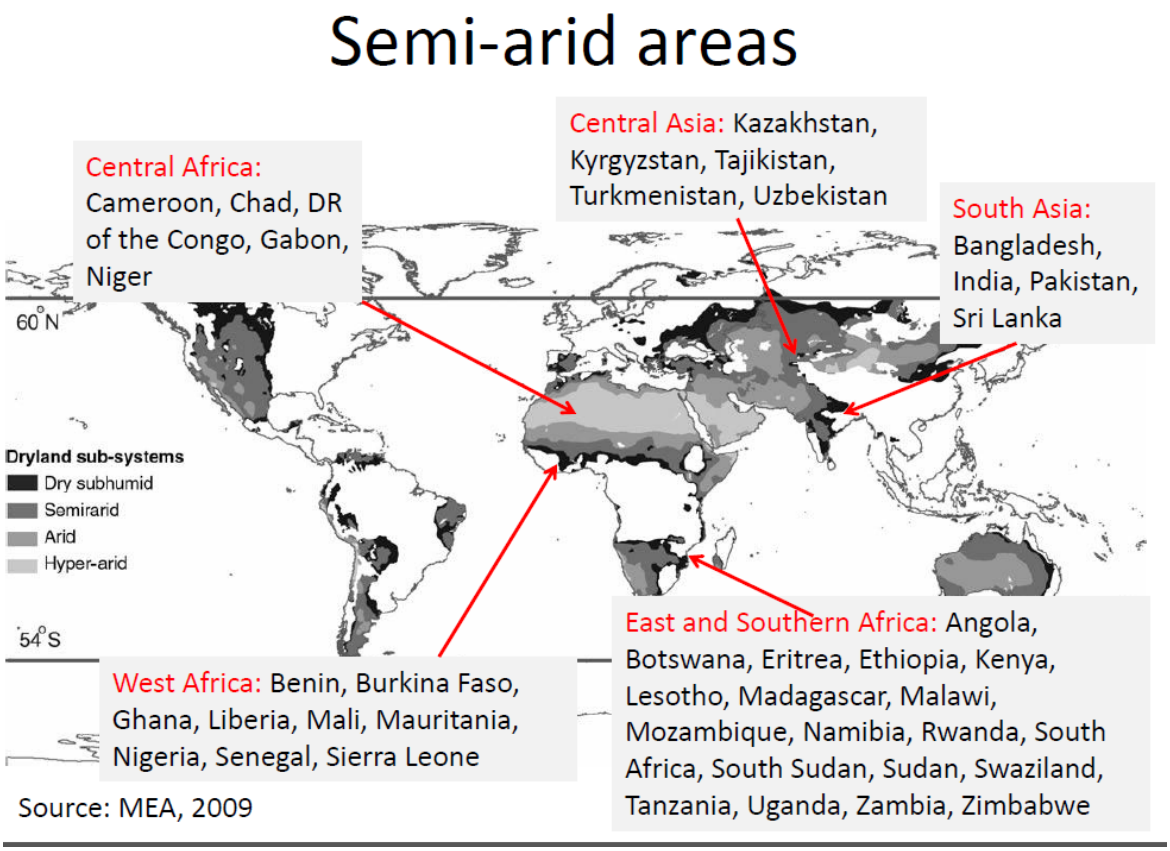
Table 1: Global extent of ASALs

Region/Area/Percentage	Arid		Semi-Arid		Sub-Humid		Total ASALs	
	(1000km^2)	%	(1000km^2)	%	(1000km^2)	%	(1000km^2)	%*
Asia (including Russia)	6164	13	7649	16	4588	9	18,401	39
Africa	5052	17	5073	17	2808	9	12,933	43
Oceania	3488	39	3532	39	996	11	8016	89
North America	379	2	3436	16	2081	10	5896	28
South America	401	2	2980	17	2223	13	5614	32
Central America and Caribbean	421	18	696	30	242	10	1359	58
Europe	5	0	373	7	961	17	1359	24
World Total	**15,910**	**12**	**23,739**	**18**	**13,909**	**10**	**53,558**	**40**

*Note: Reflects the percentage in relation to the regional total landmass.

Source: FAO (2010).

Figure 2: Global reflection of semi-arid areas



Source: Bizikova (2012).

The Environment Management Group of the UN (2011) also indicates that the majority of ASALs are located in Africa and Asia. In agreement with this, Jama and Zeila (2005) estimate that ASALs in Africa cover 1.96 billion ha in 25 countries (65% of continental landmass). Figure 2 illustrates a global reflection of ASALs.

Africa's ASALs extend above and below the equator. In the zone above the equator, Algeria, Egypt, Libya and Morocco border arid and semi-arid areas on the northern end whereas Burkina Faso, Chad and Senegal border arid and semi-arid areas on the southern end. The zones extend south-east through Somalia and northern Kenya. In the zone below the equator, ASALs cover Botswana, Lesotho, Namibia, parts of the Cape, the Northern Transvaal and Free State provinces of South Africa and parts of Zimbabwe (Bizikova, 2012).

According to Bizikova (2012), the eastern and southern parts of Africa have more countries with arid conditions than the central and western parts of the continent. Some of the countries with the largest geographical proportion of ASALs in East and Central Africa are Ethiopia, Kenya, Rwanda, Tanzania and Uganda (DFID, 2001; Jama and Zeila, 2005; Monela et al., 2005).

In agreement with this, Republic of Kenya (2012) estimates that 89% of Kenya's landmass is considered arid and semi-arid. Similarly, Mongi et al. (2010) estimate that semi-arid areas in Tanzania range from 33% to 67% and are mostly found in central and mid-western parts of north-west Tanzania. However, it is important to note that estimates for semi-arid lands in Tanzania vary considerably among different studies. While Shem (2010) estimates that nearly 80% of the land in Tanzania is semi-arid, Kangalawe and Lyimo (2013) presuppose that semi-arid areas in Tanzania occupy more than one-third of its land area.

Other countries with a significant share of arid conditions are located in Central and South Asia, specifically Tajikistan and Pakistan (Bizikova, 2012). According to Kakakhel (2011), more than 60% of Pakistan is characterised by semi-arid conditions and receives less than 2,500 mm of rainfall annually. In Tajikistan, arid and semi-arid regions cover over 143,000 km^2 of the country. According to Mustaeva et al. (2015), arid conditions in Tajikistan are expected to increase in a few decades, partly because of climate variability, which will trigger the intensity and frequency of droughts.

2.3 Population characteristics in ASALs

By 2011, ASALs were estimated to support more than 2 billion people worldwide (Environment Management Group of the UN, 2011), with about 90% of this population found in developing countries (Reynolds et al., 2007; UNEP, 2007a). However, Bizikova

(2012) reports that the population is unevenly distributed partly because of the ecological characteristics in the four sub-categories of ASALs.

According to Bizikova (2012), there is a larger population in sub-humid areas than in other ASAL sub-categories. He also indicates that sub-humid areas support about 15.3% of the estimated global population, followed by semi-arid areas with 14.4%, arid areas with 4.1% and hyper-arid areas with 1.7%. Additionally, the distribution of population varies considerably, and is largely influenced by the microclimatic conditions in each ASAL region. Comparatively, Asia has more than 40% of its population living in areas characterised by arid and semi-arid conditions, whereas Africa has close to 40% and South America has 30% (FAO, 2010).

The human population in drylands faces increased insecurity associated with land degradation and desertification. As some areas of ASALs are attracting new settlements, there is a risk of diminishing trends of productive land per capita (FAO, 2010). Nevertheless, it is difficult to provide the exact size of the population in these regions, partially because of frequent movements and spatial distribution.

Despite difficulties in providing exact figures on the population in ASALs, Jama and Zeila (2005) indicate that, by 2005, the population in ASALs had been increasing at a rate of 3% annually. This projected increase was expected to have serious negative implications for the ASALs' natural resource base, given the already fragile nature of its ecosystem (Environment Management Group of the UN, 2011). Given the increasing population in ASALs and the high dependence of this population on climate-sensitive sectors, such as agriculture and pastoralism, there is a need to devise mechanisms that will ensure these communities manage natural resources sustainably for livelihoods and ecosystem services.

Maasai woman with her herd of cows.

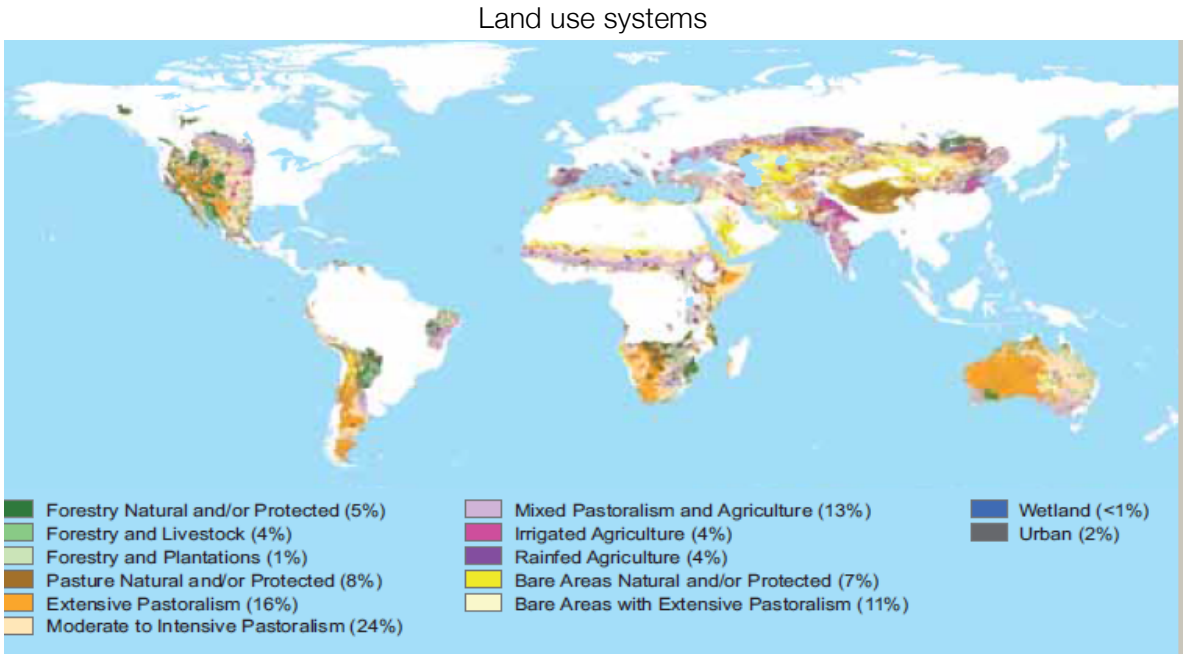
3. Land uses, ecosystems and livelihood systems

The interrelationship between ecosystems and livelihood systems in ASALs is inevitable, partly because of human dependence on ecosystem services to support critical livelihood activities, such as agriculture and pastoralism (Fabricius et al., 2008). As Mortimore notes, studies have shown that the livelihoods of ASALs communities depend on the transformation of ecosystems to earn services that drive their socioeconomic activities (cited in Fabricius et al., 2008).

In this review, transformation is conceptualised as any change in the fundamental attributes of natural and human systems that has positive or negative implications for those systems. The transformation could be related to strengthening and/or altering goals and values towards promoting adaptation or sustainable development, including addressing poverty (IPCC, 2014a).

Figure 3 illustrates various land uses supported by arid and semi-arid ecosystems.

Figure 3: Typical land uses for ASALs



Source: FAO (2010).

Bowen et al. (2012) argue that, apart from providing services, ecosystems provide support to socioeconomic development and can also contribute to coping and adaptation strategies. O'Brien et al. (2012) also indicate that a healthy ecosystem can contribute significantly to the adaptation of both human and natural systems.

As discussed in preceding sections, the Environment Management Group of the UN (2011) estimates that around 2 billion people depend directly on ASALs ecosystem services. The uneven condition of ASALs allows for various livelihood activities, including rain-fed or irrigated farming, pastoralism and/or agro-pastoralism, all of which depend on various natural resources including forestry and water (FAO, 2010).

Globally, ASALs are considered essential for supporting rangelands, which make up 65% of global ASALs (including deserts); rain-fed and irrigated farmland, which is 25%; and forests or sites for towns and cities, which is 10%. (Environment Management Group of the UN, 2011). These three primary land uses vary considerably between regions and countries, and they are likely to expand as a result of increasing investments (MEA, 2005b). In addition to the expansion of investments to utilise the potential of ASALs, droughts and loss of land productivity are also likely to affect the link between ecosystem services and human activities in ASALs, thus triggering the migration of people, which could adversely affect local, regional and even global political and economic stability (ibid.

Nevertheless, nomadic, semi-nomadic, transhumant and sedentary smallholder agricultural populations largely influence the

pattern of human dependence on ecosystem services in ASALs (FAO, 2010). Under these categories, nomadic activities are characterised by keeping livestock for subsistence and, whenever possible, farming as a supplementary activity. Many communities that carry out these activities migrate in search of pasture and water for their animals in response to the irregular distribution of rainfall in most ASALs (FAO, 2010).

On the other hand, semi-nomadic activities include a combination of both livestock and agricultural cultivation from a base camp. In some ASALs, transhumant activity, which also combines farming and livestock production during favourable seasons, is common; however, transhumant activity also involves seasonal migration corresponding to vegetation growth patterns along various physical landscapes. Finally, sedentary farming is also practised in ASALs. According to FAO (2010), sedentary (smallholder) farmers in ASALs practise rain-fed or irrigated agriculture.

In ASALs, the practice of these livelihood activities varies depending on the region. For instance, in South Asia, particularly in Pakistan, farming is a predominant livelihood activity; however, pastoralism is also practised. In other parts of Asia, especially Tajikistan, agricultural activities, such as the production of cereals and the farming of fruits and vegetables, are common in arid lands (Mustaeva, 2013; Mustaeva et. al., 2015). In West African ASALs, keeping livestock is the predominant livelihood activity; however, communities also farm. For instance, in Senegal, the production of drought-tolerant crop varieties in addition to keeping livestock is common. On the other hand, in Burkina Faso, pastoralism is the main source of livelihood. Similarly, in the East African ASALs, pastoralism is a predominant practice, but communities also farm.

In terms of socioeconomic development, East African ASALs are generally marked by low human development (e.g. high levels of poverty, low literacy); low population density but a high growth rate; and poor infrastructure (Morris et al., 2001). Poor socioeconomic development is associated with poor agricultural productivity, which is a result of unfavourable weather and soil moisture as well as few opportunities for irrigation farming (Morris et al., 2001; Sechambo et al., 1999). Other factors associated with poor agricultural productivity include the dynamics of pastoral livelihood activities, dramatic environmental changes owing to natural processes and land cover changes linked to human activities (Sechambo et al., 1999).

East African ASALs are also endowed with a large landmass that is home to a variety of natural resources rich with wildlife biodiversity, forests, wetlands and various minerals, as well as diverse cultural characteristics. Some of these lands are used for pastoralism (nomadic or semi-nomadic) or are state-controlled areas used for national parks or game reserves (Sechambo et al., 1999). In Kenya alone, ASALs hold approximately 70% of the national livestock herd and are home to most of the country's national parks, which cannot be disaggregated from wildlife tourism (Odhiambo, 2013).

In Tanzania, ASALs communities depend largely on agriculture and keeping livestock. The main crops are maize, finger millet, sorghum and cassava. Sunflower, beans, groundnuts, pigeon peas and cowpeas are also grown. Livestock-keeping is practised on a small-scale basis, and productivity depends mainly on the availability of rainfall. The types of livestock kept include cattle, chicken, goat, sheep, donkey and pigs (Odhiambo, 2013). Other key activities in Tanzania's semi-arid lands include mining, fishing and the utilisation of diverse forest products (e.g. beekeeping, lumbering, selling firewood and making and selling charcoal). Some semi-arid areas, such as Shinyanga region, are also endowed with minerals (Morris et al., 2001).

Most of the previous studies confirm the interrelationship between ecosystem services and key livelihoods in ASALs. Majule (2012) confirms that a majority of ASAL communities obtain their livelihoods through exploitation of natural resources and their products. However, as Bowen et al. (2012) point out, the transformation of ecosystems has significant economic effects and can trigger deep structural changes/problems.

Shiferaw (2006) partially highlights these problems by maintaining that the transformation of natural resources has resulted in the degradation of the natural resource base. Fabricius et al. (2008) indicate that the interrelationship between human communities and the environment is largely jeopardised by the rapid increase in population, which triggers ecosystem transformation beyond the tolerance level of ecological carrying capacity (also Shiferaw, 2006). This has resulted in a decline in the supply of ecosystem services and has triggered high levels of poverty and long-term vulnerability (Fabricius et al., 2008).

Ecosystem changes also influence the microclimate and livelihood systems of ASALs communities (Fabricius et al., 2008). Interestingly, some studies report that type of land use and land cover influence rainfall distributions in arid and semi-arid climates (MEA, 2005a). Nevertheless, throughout the past three decades or so, forested land is said to have decreased extensively in East Africa – including in ASALs – at a rate of 1% to 4%, with a 2% reduction in forests in

"Technological advancements could possibly harness existing opportunities, enhancing communities' abilities to cope with and adapt to the impacts of climate change."

Kenya, 1% in Tanzania and 4% in Uganda (Mwiturubani, 2010). This is attributed to both natural and human factors (Fabricius et al., 2008).

In addition to human consumption patterns, weak governance regimes, when coupled with natural stressors such as climate change, also contribute to environmental degradation (Fabricius et al., 2008). In the long term, these processes, together with inadequate opportunities to earn livelihoods and underinvestment, translate into the impoverishment of ASAL populations (Jama and Zeila, 2005).

Heavy dependence on traditional livestock-keeping systems (a main feature of which is large-numbered herds) also contributes to the marginalisation of ASAL communities (Jama and Zeila, 2005; Nori et al., 2008). Nori et al. (2008) consider pastoralism as a complex livelihood option that integrates people, livestock and pastures in ASALs' harsh and stressful environmental conditions.

It has been claimed that pastoralists in East Africa are largely nomadic and keep livestock, such as cattle, sheep, goats and camels (Odhiambo, 2013; Rowlinson et al., 2008). They typically inhabit areas where scarce resources and extreme climatic conditions limit options for alternative land-use and livelihood systems (Nori et al., 2008).[3]

Another common feature of pastoral areas is a high rate of unsuccessful development programmes, partly because of farming and factors associated with policy, planning and decision-making processes. The insecurity of tenure and the mobile lifestyle of most pastoral communities also contribute to intervention failure and a misconception among decision-makers on the low prioritisation of ASAL development interventions (Nori et al., 2008).

The marginalisation of ASAL communities is also influenced by a number of inherent structural systems that challenge human ingenuity and adaptability (Fabricius et al., 2008). These include weak institutions, poor governance and infrastructural dysfunctions (Shiferaw, 2006) as well as lack of support to promote pastoralism for national development (Odhiambo, 2013). For instance, implementation of structural adjustment policies in Burkina Faso is believed to have paralysed the yield of such major crops as millet, sorghum, rice and maize (Environment Management Group of the UN, 2011). As a result, most ASALs are less developed and thus more exposed to multiple shocks and stresses, including the impacts of climate change.

Fabricius et al. (2008) indicate that livelihood systems in ASALs, especially in rural settings, are also influenced by variable climatic conditions, the impacts of which are magnified by poor technology. A key assumption is that technological advancement could possibly harness existing opportunities, enhancing communities' abilities to cope with and adapt to the impacts of climate change (Fabricius et al., 2008; Madzwamuse et al., 2007).

Shiferaw (2006) adds that the marginalisation of ASAL communities is compounded by the scarcity of productive lands. It is further indicated that scarce land induces low productivity and sometimes leads to environmental degradation. This is partly because poverty deprives a household of its ability to make viable investments to improve land productivity and ultimately development. Shiferaw (2006) indicates that poverty can

[3] There is a need to have clear and rigorous definitions of concepts such as 'pastoralism', 'transhumant' and 'nomadism'. As Benjaminsen et al. (2009) note, concepts like 'nomadic pastoralism' have been perceived by authorities in Africa since the colonial period, and later by most of the development aid industry, as an unproductive vestige of the past.

further be categorised into 'welfare poverty' and 'investment poverty'. Welfare poverty focuses on the ability of a household to attain basic consumption needs, whereas investment poverty focuses on the ability of a household to invest in and improve natural resource management (e.g. soil conservation, fertiliser use and tree planting, small-scale irrigation).

Hence, the ability of a household to invest in resource improvement requires a household to have enough capital to own key assets needed to make such investments (Shiferaw, 2006). Capital for investment must also be above and beyond requirements for a household's basic needs. Fabricius et al. (2008) indicate that the world's poor have a reduced capacity to compensate for environment flow in situations where ecosystem services are compromised, making them susceptible to ecosystem degradation in the short term.

Low natural resource endowment also contributes to the vulnerability of ASAL communities. According to Fabricius et al. (2008), most ASALs are characterised by poor soils and low levels of natural resource productivity, sparse vegetation cover and relatively limited surface water resource endowment. Besides low natural resource endowment, harsh climatic conditions in ASALs are also culprits in terms of forcing residents to migrate to humid areas, searching for favourable pastures and lands (Wiskerke, 2008).

According to Shem (2010), high numbers of livestock necessitate frequent movements of people from areas that traditionally had few livestock, such as Mbeya, Iringa, Morogoro, Rukwa and the coastal areas (in Tanzania). Unfortunately, such movements cause serious land-use conflicts between livestock keepers and crop farmers. These conflicts exist despite historical compatibility between the two groups, and they are largely linked to rapid population growth and structural factors, such as agricultural policies that aim to expand agriculture without considering the mobility of pastoral communities as a viable economic mode of production (Benjaminsen et al., 2009; Hesse and MacGregor, 2006).

Other factors that mobile pastoralists face, besides the harsh environment, include the effects of human settlement, state encroachment, poor infrastructure and hostile market mechanisms (Wiskerke, 2008). Public policies do not promote adaptation options that encourage pastoralism and eventually contribute to sustainable rangeland management. Policy support to other land uses, such as wildlife conservation and mining, has contributed to the dispossession of pastoralists from rangeland resources (ibid.). For instance, wildlife conservation, in the form of national parks and game reserves, has deprived many pastoral communities of their traditional homelands, thus diminishing land per capita and creating chaotic mobile livelihood activities (Shem et al., 2005).

As such, pastoralists' ability to respond to environmental stresses, including those associated with climate variability and change impacts, are reduced considerably (Shem, 2010). In some instances, this has also magnified the severity of climate change impacts on pastoral communities. In Tanzania, pastoralists cope with these stresses through continued movements in search of pasture, arable land and sometimes settlement (Shem, 2010). The mobility of pastoralist communities, as well as other communities living in ASALs, is expected to increase partly because of the impacts of climate change, which are likely to stress adaptation and coping strategies of indigenous communities (Fabricius et al., 2008; IPCC, 2007). The mobility of people in search of favourable climatic conditions is also likely to lead to conflicts (O'Brien et al., 2012; IPCC, 2014a).

Barnett and Adger (2007) and Mwiturubani (2010) indicate that conflicts could result from competition between land-use groups, such as livestock keepers and crop farmers. For instance, as O'Brien et al. (2012) highlight, the migration of pastoralists to areas with communities currently engaged in crop production can trigger competition over water use and eventually micro-scale conflicts, which can evolve to large-scale conflicts. Given such socioecological dynamics, any efforts to reduce vulnerability in drylands will need to conserve natural resources, improve access to markets and strike a balance between livelihood systems and population growth (Paavola, 2004). Shiferaw (2006) also recommends policies be clear on tenure issues, especially for land that determines key production patterns.

As an intervention to improve livelihood systems, various ASAL communities have changed their household activities. For instance, as Fabricius et al. (2008) report, communities now view small stock farming as a way to protect themselves against unemployment rather than a central economic activity. While changing livelihood systems is envisaged as a viable coping and adaptation option (ibid.), low productivity of natural resources, such as ASALs' low soil fertility owing to lack of organic matter and vegetation cover, will further impede the viability of some survival strategies, for example agro-pastoralism (FAO, 2010).

Shiferaw (2006) suggests the improvement of livelihood systems in ASALs will depend on the intensification of land use for agriculture and other key sectors. Additionally, innovations for natural resource management have the

potential to make a significant contribution to the improvement of ecosystem services, which have an indirect and direct contribution to ASALs livelihood systems (Shiferaw, 2006).

Environmentally sustainable activities and climate-compatible options, such as beekeeping and Climate Smart Agriculture, respectively (the latter of which combines soil and water conservation strategies), could be called on as viable options to address the combination of risks induced by the low productivity of natural resources as well as harsh climatic conditions. According to Eyzaguirre and Dennis (2007), Madzwamuse et al. (2007) and Fabricius et al. (2008), strategies used to improve the genetic diversity of crops and livestock may ensure the sustainability of ASAL agriculture and livestock production.

Handful of Maize
© Cilia Schubert

4. Global perspective of natural capital endowment and drivers of change

According to Brand (2008), natural capital is any stock of natural resources or environmental assets that provides a flow of useful goods or services for present and future generations. Both Aronson et al. (2006) and Brand (2008) indicate that natural capital is used widely to signify various components (e.g. resources, biodiversity, fertile soil, ozone layer), properties (e.g. ecological resilience, ecosystem health, integrity) and dispositions (e.g. regulative or assimilative capacities). Similarly, Ehrlich et al. (2012) conceptualise natural capital as capital stock from which people derive vital ecosystem services. According Ehrlich et al., the stock is used for the production of goods (e.g. food, timber, industrial products), regulating services (e.g. water purification, crop pollination, coastal protection), cultural benefits (e.g. inspiration, recreation) and preservation. Shiferaw (2006) and Brand (2008) indicate that the stock of natural capital can be depleted if overused. Therefore, sustainable measures must be undertaken to protect natural resources for current and future generations (Brand, 2008).

Apart from the analysis of natural capital, drivers of ecosystem change have also been thoroughly studied, and they operate at global, national, local and household levels. Fabricius et al. (2008) further expound that drivers of ecosystem change have varying effects and that these are felt at different spatial scales and appear over different lengths of time; thus, it seems the significance of ecosystem change drivers varies depending on the region and the time (ibid.).

Furthermore, the effects of any specific driver are also dependent on the context in which it is felt as well as the previous or current operation of other drivers (Fabricius et al., 2008). Often other drivers of ecosystem change are a result of interventions to address socio-environmental problems. For instance, while the provision of secure water supplies through the exploitation of underground water can reduce the vulnerability of dryland inhabitants, if not managed well such exploitation can undermine the ecological resilience of the drylands (Fabricius et al., 2008).

Subsequent subsections discuss key drivers of ecosystem change including natural resource degradation, which is largely associated with natural and structural processes; climate change impacts, or stresses induced by the changing climate; poor governance; land-use change; unplanned migration and associated conflicts among resource users; and demographic shift.

4.1 Natural resource degradation

Birch-Thomsen et al. (2001) define natural resource degradation as the processes of environmental change that lower the potential of production and other natural resource use within present production systems and natural resource management. Land degradation therefore relates to patterns of current resource use.

Degradation of the natural resource base is one of the major development problems in the ASALs of Sub-Saharan Africa and Asia (Shiferaw and Bantilan, 2004). It has been attributed to the loss of 4% to 8% of annual gross domestic product (GDP) in most developing countries (Environment Management Group of the UN, 2011).

According to the Environment Management Group of the UN (2011), approximately 6 million km^2 of drylands (about 10%) bear a legacy of land degradation. Environmental degradation linked to pressure on natural resources has become evident, especially in ASALs (Monela et al., 2005). For instance, Tanzania's Shinyanga region has been degraded and most of its land deforested (Monela et al., 2005; Wiskerke, 2008). Unsustainable land husbandry practices, a rapidly rising livestock population and a burgeoning human population continue to exert pressure on land and forest resources in this area, which consequently leads to further land and forest degradation (Monela et al., 2005; Msangi, 1995).

As well as highlighting institutional, governance and policy dysfunction, climate change underpins issues concerning land-based resources (Lyimo and Kangalawe, 2010; Rowlinson et al., 2008). Shiferaw and Bantilan (2004) indicate that insecure tenure rights of natural resources (land, water and forests), which are largely linked to poor institutional framework, will aggravate natural resource degradation in ASALs. Natural resource degradation will further aggravate poverty in most poor ASAL communities (Monela et al., 2005).

These circumstances will create a poverty–environment nexus that will further trap the poor in the cycle of poverty and natural resource degradation. Breaking this poverty–natural resource degradation nexus

requires investments in human and natural capital, proper public policies and agricultural research to strengthen local institutions and engage the private sector and other non-governmental actors, improve market access and create other development opportunities (Bowen et al., 2012; Shiferaw and Bantilan, 2004).

Monela et al. (2005) recommend that strategies to reduce natural resource degradation in semi-arid areas include introducing zero grazing, fodder production, demarcation of designated grazing lands and pasture management and destocking.[4] However, according to these authors, successful implementation of those strategies must go hand in hand with the institutionalisation of systems for savings, investment and food security, particularly services for livestock keepers who largely depend on traditional institutions to cope and adapt to climate change impacts.

4.2 Climate change impacts

Over the past few decades, climate change has been cited as one of the key drivers of both human and natural systems that impacts socioeconomic activities and transforms ecosystems across scales (Boko et al., 2007; IPCC, 2014b). Fabricius et al. (2008) indicate that the depletion of natural resources augments the severity of impacts owing to climate change and variability, eventually reducing the capacity of ecosystems to deliver services.

From this, it is clear that human activities in ASALs are increasing ASALs' vulnerability and altering ecosystems by inducing shifts in habitat distribution (Bowen et al., 2012; Fabricius et al., 2008). Changes in habitat distribution could result in changes in habitat quality and shifts in species distribution, which can move species outside of preferred habitats (Dullinger et al., 2012; IPCC, 2014a; Urban et al., 2012).

Additionally, the changing climate can aggravate biodiversity loss and land degradation, and trigger other drivers of environmental change such as unsustainable farming practices (Foley et al., 2005). Climate change is also projected to be a powerful stressor for ecosystem changes in the second half of the 21st century, especially under high-warming scenarios. However, the severity of change will be accelerated by direct human impact, such as land-use change and environmental degradation.

The Intergovernmental Panel on Climate Change (IPCC) (2014a) names land-use and cover change as one of the key drivers of current ecosystem and biodiversity change. The changes, especially in tropical and subtropical areas of Asia and Africa, are characterised by the conversion of forests and woodlands to other land uses, such as crop farming, livestock-keeping and agriculture (Hosonuma et al., 2012; IPCC, 2014b; Macedo et al., 2012).

Boko et al. (2007) and Mbilinyi et al. (2013) indicate that impacts are likely to be severe in areas where the economies of many communities are dependent on sectors that are vulnerable to climate conditions, such as agriculture; ASALs are among these areas. Mbilinyi et al. (2013) argue that additional stresses to these communities and ecosystems (e.g. higher temperatures, droughts and dry spells, more inconsistent rainfall and torrential downpours) will increase risks of low moisture and soil erosion, thus leading to low land productivity. Climate change will also aggravate stress on water resources, especially in the drylands (Boko et al., 2007; Mbilinyi et al., 2013).

Additionally, climate change is expected to have multiple effects on communities in ASALs, with each effect being a driver in its own right and compounding existing pressure on ecosystems and speeding up loss of biological diversity, inducing changes in the spatial distribution and productivity of wild species and reducing the distribution and availability of water resources (Bowen et al., 2012; Mbilinyi et al., 2013). Climate change is also projected to further shrink rangelands in ASALs. Such rangeland shrinkage is likely to exacerbate conflicts between livestock keepers and farmers in many areas (Mwiturubani, 2010; Shem, 2010). In this regard, poverty alleviation and food security will assist in climate change adaptation and improve livelihood strategies in ways that ensure the survival of communities in a risky environment (Shiferaw and Bantilan, 2004).

The effects of climate change are expected to have a bigger impact on poor members of ASAL communities who are highly dependent on natural resources and have a limited capacity to adapt to the changing climate (Kangalawe and Lyimo, 2013). It is also expected that rainfall and temperature patterns will have an effect on the availability of water, which can consequently have severe impacts on rain-fed agricultural production (Fabricius et al., 2008; Kangalawe and Lyimo, 2013). As a consequence, the amount of land suitable for crop production and crop yields is also likely to decrease.

[4] However, there is a need for a thorough analysis of the perceptions of the environment that view 'natives' as suffering from a 'cattle complex', which leads to 'over-stocking'. Destocking schemes have been tried and failed since colonial days. Also, the post-colonial pastoral policy discourse in Africa has been largely influenced by modernisation ideology, viewing pastoralism as an unproductive and environmentally damaging relic of the past.

It is expected that 'even a slight increase in temperature or change in precipitation could produce a striking change in vegetation which would exacerbate impacts of trends in degradation in the arid rangelands' (Fabricius et al., 2008: 19). In his analysis of Tanzanian policies, Lugoe (2011) notes that climate change has negatively affected rangeland management among poor pastoral communities in the ASALs, particularly those in central and northern Tanzania.

4.3 Poor governance

Governance drivers are differentiated by scales; there is the global scale, which includes multilateral agreements like UNCCD that take years in negotiations, and the national scale, which waits for any global agreement to be passed down for uptake into legislation and policies, something that also takes time and is later implemented (Lankford et al., 2007).

In other words, the governance process takes a long time. Thus, changes in ecosystems that are a result of global environmental governance are slow (Fabricius et al., 2008). This is unlike some changes in ecosystems that are as a result of local governance initiatives. 'Local governance arrangements are necessary to cross scales and link policies from higher levels to local action on management drivers in some contexts, local governance is capable of promoting rapid impacts' (ibid.: 19).

One of the noted factors reducing the effective management and regulation of ecosystem services is the move from using traditional authorities to more 'modern' ones (Fabricius et al., 2004; Lawes et al., 2004). However, in situations where there has been improved governance, the devolution of decision-making was credited (e.g. biodiversity in conservancies of Namibia) (ibid.). Still, the effectiveness of the devolution of natural resource management remains unclear, causing mixed feelings on the subject. According to Fabricius et al. (2004), devolution of natural resource management often places additional risks and responsibilities on the poor, which they are not prepared or equipped to deal with.

Semi-arid areas of Tanzania

"The amalgamation and privatisation of land resources in higher-potential rangelands, some of which can be found in parts of the drylands, contribute to non-climatic stress on the livelihoods of ASALs."

4.4 Land-use change

Changes in land uses, including the conversion of traditional dry-season grazing reserves and land adjudication, have been observed in both Tanzania and Kenya. According to Jama and Zeila (2005), the state in Kenya has expropriated some dry-season grazing areas of the Maasai and the Boran as protected land (e.g. national parks and game reserves), thus denying pastoralists access to these sites. Unfortunately, these sites are especially important for supporting dry-season grazing activities. Localised land-use changes, including farmers now occupying major livestock migratory corridors, also place other stresses on pastoralism activities. Along the corridors of the Tana transect in Kenya's Garissa district, pastoralists are being denied access to the river that is traditionally their area for watering livestock. These circumstances have, in most cases, caused violent conflicts (Jama and Zeila, 2005).

Jama and Zeila (2005) argue that the amalgamation and privatisation of land resources in higher-potential rangelands, some of which can be found in parts of the drylands, contribute to non-climatic stress on the livelihoods of ASALs communities. These processes have contributed to an exertion of pressure on the drier parts of the drylands. Although these processes are conducted in the name of natural resource conservation, they have resulted in many unforeseen problems, including land degradation and hostile relations between pastoralists and farmers.

Other consequences of this policy approach include making the majority of ASALs communities landless. Taking away land from the people, especially farmers, will result in them migrating to marginal areas, thus creating environmental problems. Second, the amalgamation of land is often followed by the fencing-off of land, which eventually interrupts the free movement of wildlife and livestock (Jama and Zeila, 2005).

4.5 Migration and conflicts over land resources

In most cases, pastoral communities in ASALs consider migration as a primary coping strategy. Movement is focused on areas where there is pasture and water (Shem, 2010). For example, the availability of livestock feeds and water in wetter parts of Tanzania, like the Kilombero River and Ruaha River sub-catchments, have attracted a number of livestock keepers from drier parts of central Tanzania (Majule, 2012). High mobility induced by lack of alternative livelihoods, competing user rights and unclear entitlements, plus increasing human and livestock populations, is expected to further aggravate conflicts (Shem, 2010).

Many pastoral communities in Tanzania have already fallen victim to unplanned migration and conflicts with other land users (Shem, 2010; Shem et al., 2005). According to Shem et al. (2005), the livestock population in most areas of Tanzania has surpassed normal carrying capacity. The increasing number of cattle, coupled with environmental stresses from the changing climate, has contributed to the high mobility of large livestock herds to less populated areas (Benjaminsen et al., 2009; Shem, 2010). The migration of pastoral communities has often resulted in violence, particularly over the allocation of land and water resources. Even if mobile livelihood strategies are restricted, these areas are already marginalised and severe environmental problems are likely to occur in the near future (Shem, 2010).

As a result of unplanned immigration, civil conflicts have occurred between livestock keepers and farmers over pasture and water.

Similarly, the mobility of cattle keepers in search of pasture and water mean school dropouts have grown rampant in pastoralist communities (Shem, 2010). As Bowen et al. (2012) point out, increased dropouts and poor school attendance expose pastoral communities to climate risks and reduce their capacity to cope with and adapt to climate impacts.

This is largely the case because education is one of the less costly strategies for coping with and adapting to climate change impacts (Bowen et al., 2012). Bowen et al. also argue that information is a powerful factor in resilience to climate change. Therefore, increases in school dropouts owing to unplanned migration call for policy action, which includes supporting sedentary livestock-keeping (Shem, 2010).

Mobility is also expected to further increase competing land uses and conflicts between various types of land use (e.g. livestock keepers and crop farmers) (Shem, 2010).

However, in some areas, such as the Usangu Plains in Tanzania's Mbeya region, immigrant pastoralists and indigenous ethnic groups, who are mainly agriculturalists, have forged complementary coexistence (Kajembe et al., 2003; Shem, 2010).

4.6 Demographic shift

Population figures and projections for Sub-Saharan Africa show many countries face the prospect of doubling their populations between 2002 and 2025 (Fabricius et al., 2008). The increased population will result in various developmental challenges. Along with rapid urbanisation, which is also associated with improvements in communication technologies and increased global connectivity, the population increase will eventually exert a high demand for products from natural resource- and land-based sectors such as agriculture.

Fabricius et al. (2008) further argue that, although drylands are still preoccupied by traditional modes of production, such as pastoralism, rapid urbanisation means younger generations may prefer to seek alternative livelihood options in towns and cities rather than in pastoral lands. Consequently, there is a likelihood of an outstanding erosion of local knowledge, as the next generation grows up in urban areas (Fabricius et al., 2008).

It is also important to note that the sustainability of urban populations will depend on the supply of natural resource-related products and services (e.g. industrial raw materials, fuelwood, food and water supply), many of which are harvested from vulnerable ecosystems including drylands. Similarly, if properly planned and managed, urbanisation can revitalise rural economies (Fabricius et al., 2008). Therefore appropriate policies should be formulated to synergise and tap into opportunities emanating from the population increase and the provision of ecosystem services.

Sahel food crisis

5. Regional perspective of natural capital endowment and drivers of change

This subsection provides summaries of key issues on natural capital endowment and drivers of change from three PRISE regions: West Africa, East Africa and Asia.

5.1 Natural capital endowment and drivers of change in Senegal and Burkina Faso

Senegal and Burkina Faso are relatively rich in natural resources because they belong to the Sudano-Sahelian zone. Two major ecosystems that dominate these countries are shrubby savannahs and steppes (Hountondji, 2008; Sambou, 2004). This owes mainly to climatic drought and a significant decrease in rainfall from the south to the north. For example, the 1996 Senegal aridity map drawn by the Ecological Monitoring Centre reveals that, in 50 years, the extreme north of the country will be taken over by the Saharan-Sahelian area (100-200 mm) and the 400 mm isohyets will move nearly 100 km south (CSE, 2010; Diagne, 2000).

Similarly, a map of Burkina Faso reveals a decline in rainfall observed from 1960 to 1969 resulted in the disappearance of the 1,200 mm isohyets of the country (Tiendrebeogo, 2013). This climatic deterioration means over 11% of the country's land is now considered highly degraded and 34% moderately degraded. The consequences are reflected at the country level by a deterioration of economic goods (e.g. water, soil, plants) and uncertainty in the country's important development sectors (e.g. agriculture, livestock, forestry).

In this context, the populations of Burkina Faso and Senegal depend heavily on primary sectors that rely strongly on natural resources (e.g. agriculture and livestock-keeping); this results in precarious living conditions. Therefore, drought cycles observed in these countries, as well as temperature increases, have had impacts particularly on the productivity of agricultural and livestock areas.

Senegal's inland regions, which also coincide with areas of agricultural and livestock production, are the most affected and have the highest level of poverty. In Burkina Faso, a study by Batana et al. (2012) shows that the northern and central tray (considered the most arid area of the country), where the principal activity is pastoralism, poverty often exceeds 55%, especially among women.

Degradation of natural capital in the Sahel cannot be blamed only on climate change. Renewable natural capital in these countries (e.g. ecosystems, species living) is also affected by poverty, insufficient resources (financial, technological), low response capacity of stakeholders to climate hazards, inappropriate political orientations, lack of long-term planning and production systems that destroy natural habitats (extensive farming, monoculture).

Finally, the heavy dependence of rural populations on natural capital also induces the degradation of natural resources, specifically if the utilisation rate is greater than its renewal rate (MECV, 2010; Ngaido, 2002; PASEF, 2010). Thus, beyond the sectors closely related to natural resources in both countries, such degradation of natural capital has consequences that also affect social capital, territorial dynamics and social relations.

For example, in Burkina Faso, ecosystem degradation on agricultural land has resulted in population movements from dryland areas to the most fertile areas, which has resulted in an exacerbation of social conflicts between migrants and indigenous peoples (Djiga, 2009). According to Robert (2010), an increase in conflicts between livestock keepers and farmers was also observed as a result of the uncertainty of pastoral activity; livestock keepers affected by the gradual reduction of grazing land, lack of access to resources such as grazing areas and water sources and lack of adequate policies and infrastructure need to be closer to fertile land and therefore farmland.

5.2 Natural capital endowment and drivers of change in Pakistan

Natural resource endowment

Pakistan's key economic sectors are dependent on a sustainable supply of services from key natural resources such as land, water and forests. For instance, water supply for irrigation enhances agricultural productivity.[5] Hence, the

[5] Pakistan owns the largest contiguous irrigation network in the world. Its large tracts of semi-arid lands are interconnected with an intricate network of rivers, dams, barrages and canals that irrigate farmlands across Punjab, Sindh and Khyber Pakhtunkhwa province (KPK). Presently, 90% of the food and fibre produced comes from

decreasing supply of water resources under current climatic and non-climatic stresses will have significant negative implications for agricultural productivity (GoP, 2009). Forests are important for the conservation of the water catchment, thus contributing to the improvement of water flow and dams that help meet the hydroelectric needs of the industrial sector. Northern areas of Pakistan (Gilgit-Baltistan province) receive heavier annual precipitation and are generally well endowed with dense forests and rich minerals.

Arid Balochistan province is blessed with coal and natural gas reserves, which are distributed to the rest of the nation. Sindh province is the main contributor to fisheries sector. The Punjab is known as the bread-basket of Pakistan and generally contributes handsomely to the national economy through agricultural productivity in important cash crops and value-added sectors (e.g. textiles).

Khyber Pakhtunkhwa province (KPK) is rich in various natural resources. Its most important contribution comes in the form of hydroelectricity production, which helps meet Pakistan's energy needs. The Punjab, KPK and Sindh are also important agricultural provinces that generate food and livestock. While Pakistan is well endowed with diverse and rich natural capital, this paper reviews only three vital natural resources: forests, water and land.

Forests

Forest resources are important for the supply of services that cater for human needs and environmental conservation across scales (GoP, 2005; Khan and Mehmood, 2003; Saeed, 2003). The roles of forests in soil and water conservation are distinct when it comes to the maintenance of ecological balance, which includes water flow and ecosystem services (Khan and Mehmood, 2003). In Pakistan, forest resources provide raw materials important for forest-related industries, which ultimately support employment in the country. They also provide fuelwood for more than 100 million people (57% of the total population), and grazing land for more than 90 million people (Bhatti, 2011; FAO, 2014).

Over the past two decades, institutional changes have been introduced in the forest sector, including the establishment of institutions to support the implementation of participatory management approaches in order to empower communities (Geiser and Steimann, 2004; Shahbaz et al., 2006). However, community empowerment through modern participatory approaches for forest management have not been realised, and traditional management practices (e.g. Jirga) are largely dominant (Sultan-i-Rome, 2005, 2013).

Water

The Indus River System (IRS) is the only freshwater source to feed Pakistan's expanding economy. Kiani notes that six major waterways of the IRS are largely dependent on glacier melt from the Himalayan Mountain Range (70% to 80% of its flow) (as cited in Wong et al., 2007). About 95% of IRS water withdrawals are diverted for agricultural use (FAO, 2011a; GoP, 2009). Other agricultural activities are subject to seasonal rainwater.

Land

Agriculture is one of the main land uses in Pakistan and is largely dominated by small-scale landholders. As a result, many of those landholders are being blamed for the transformation of socioecological landscapes and the alteration of natural habitats.

Key drivers of change in the ASALs of Pakistan

Natural drivers of resource degradation

Land degradation and desertification is a major threat for natural resource-based livelihoods. According to the Taskforce on Climate Change in Pakistan, about 38% of agricultural land in the country is prone to various forms of degradation (GoP, 2010). The adverse effects of land degradation are many, including the deterioration of the drylands ecosystem, nutrient depletion in soil, intensive flooding, biodiversity loss, low productivity of land, soil erosion and other problems related to a rapidly increasing population (Rasul et al., 2012).[6] The situation is worsened by water shortages and the mismanagement of land resources. The combination of these factors has resulted in negative effects on rural livelihoods as well as the supply of agricultural products to urban areas.

Climate change

Maplecroft ranks Pakistan as the 12th worst climate change affected country in the world. Losses in terms of GDP are almost US$2.4 billion per year (as a result of extreme events only).

With a projected increase in temperature of about 5°C by the end of the 21st century, the livelihoods and food security of millions will be affected as crop production declines and crop water requirement rises (Rasul et al.,

irrigated lands (the rest comes from rain-fed lands).

[6] Land degradation by wind erosion is a common phenomenon in arid (and coastal) areas of Balochistan, Sindh and Southern Punjab, whereas water erosion has acutely degraded land in Punjab and KPK (Potohar region and the plains along the Sulaiman range).

2012).[7] The UN Economic Commission for Asia and the Pacific (UNESCAP) states that, by 2025, water availability per capita is also predicted to decline to 800 m^3 (cited in Romshoo, 2012; also GoP, 2007). The decline in water resources will affect millions of poor people, and make them more vulnerable to extreme climatic events, as witnessed during the 1999/2000 drought in the Balochistan drylands. Extreme water stress resulted in livelihood losses that mostly affected smallholder farmers who had less diversified assets on which to rely (e.g. livestock-keeping and fruit crops) (FAO, 2011a).

Human drivers of degradation

Population growth: Pakistan is the world's sixth most populous country with a population of 188 million people (GoP, 2013) and an exceptionally high population growth rate of 2% (the 1990-2010 average). This means more resources (e.g. water, food, energy) are required to meet primary human needs. With the population expected to rise to 242.06 million by 2030 (ibid.), slums in urban and peri-urban areas are likely increase, thus contributing to natural resource degradation, partly because of poverty, poor services and the increasing effects of climate change.

Urbanisation and industrialisation: Urban Pakistan is home to 72.5 million people or 38% of the total population (GoP, 2014a). Pakistan has one of the highest rural-to-urban migration rates in South Asia, indicating a shift in livelihood patterns. While urban incomes may not entirely be natural resource-dependent, urbanisation does exert pressure on natural resources by creating demand for water and food and deforestation for housing and infrastructure development.

Unsustainable resource use: Intensive cultivation has resulted in land degradation in many areas. About 70% of farmers in Pakistan are smallholders with limited land per capita and who implement unsustainable land management practices, such as the excessive application of fertilisers and pesticides to maximise production in order to feed a growing population. Such practices have resulted in land degradation (PARC, 2002).

Key issues and policy implications

Natural resource degradation

With rapid population growth, rapid urbanisation, industrialisation and agricultural expansion, Pakistan's natural resources are likely to face serious degradation. As the country's aquifers are dumped with agricultural, municipal and industrial effluents, an alarming number of households have become susceptible to waterborne diseases and related health problems through consuming poor-quality water. Although legal regulations exist for water quality control, such as Pakistan's Standards and Quality Control Authority's Water Quality Standards and Pakistan Environmental Protection Authority's National Environmental Quality Standards, weak implementation means they fail their original purpose.

Women, resource depletion and livelihoods

As in other developing countries, in rural Pakistan, women are primarily responsible for securing household water supplies. Rural provinces Sindh and Balochistan are susceptible to water shortages and show a marked increase in the time rural women spend collecting water (World Bank, 2005). A decline in access to water results in an increased amount of time spent collecting water, thus lessening the time women could spend on economic activities (ibid.). In such cases, it is the rural women of the population who stand to lose the most from climatic change as seasonal and long-term fluctuations in water availability erode rural livelihoods and subsistence incomes that women derive from agriculture, livestock and the traditional handicrafts and cottage industries.

Inequity in resource distribution

Land is important natural capital for the rural economy of Pakistan. Unequal land distribution is one of the major factors contributing to poverty in many rural areas of Pakistan (Anwar et al., 2004; USAID, 2010). Even though several land reform attempts have been made to ensure fairness in land distribution (1959, 1972 and 1977), many of these have failed to deliver expected results, for a variety of reasons (Niroula and Thapa, 2005), including poor governance.

Inappropriate policies

Natural resource degradation and issues of environmental concern often arise as a result of poorly targeted policies or initiatives. While the National Climate Change Policy of Pakistan (2012) recognises that water stress will be an issue in ASALs and affect agricultural production, the Government of Pakistan continues to invest in fancy irrigation schemes that focus on maximising water utilisation in agriculture rather than optimising water efficiency and usage. In FY2014/15, 87% of the total budget set aside for the water sector is to be utilised for irrigation projects (GoP, 2014a).

Clearly, environmental problems are exacerbated as a result of inappropriate policies that are rather detrimental to the natural resource base. Pakistan's major economic sectors (agriculture, energy and industries) are critically dependent on ample water supplies.

[7] Crop production in Pakistan is also expected to decline because of the indirect effects of climate change. For example, enhancing soil processes, such as de-nitrification, leads to the emission of greenhouse gases, but the unavailability of plant nutrients increases crop water requirements.

For instance, subsidisation of the water supply in order to incentivise economic growth has been resulting in inefficient usage. Moreover, the overuse of subsidised water has resulted in waterlogging and soil salinity in many irrigated lands. Similarly, energy subsidies on natural gas and petroleum have led to not only the depletion of this natural resource but also higher emissions.

Similar policies in ownership and tenure rights have affected the land-use and forestry sectors. The abolishment of communal land management in the 1970s and the introduction of state ownership of uncultivated land have been blamed for triggering land degradation because government control over land is relatively weak and lacks ownership or tenure rights. More importantly, most development policies have been associated with the change of government and are often critiqued for being top-down, autocratic and non-inclusive. Despite having an established environmental policy and legislative framework, implementation is rather weak.

Conflict over resource use

Despite introducing a series of institutional reforms for decentralisation in the forestry sector, there is enormous conflict between local forest users and state authorities on forest rights (Sultan-i-Rome, 2005). These conflicts are largely linked to state interference with traditional forest resource management systems, especially in many parts of KPK (Sultan-i-Rome, 2013).

Development policy and planning

While Pakistan has a number of short- and long-term development plans and some very good policies, there is a disconnect between policy and practice. There is also a lack of coordination between the core ministries; for instance, the Ministry of Planning, Development and Reforms[8] often sets development targets and plans, but the Ministry of Finance often fails to release the needed budget to meet those very development targets.

5.3 Natural capital endowment and drivers of change in Tajikistan

Tajikistan's natural capital is mostly concentrated around water, land and forests. It is one of the richest countries in the world in terms of water resources. It provides 64 billion m^3 of water annually, accounting for more than 60% of river flow in the Aral Sea Basin. Only about 10% of river flow emerging in the country is used for domestic needs; the rest of the water flows into countries downstream and is mainly used for irrigation purposes (UNDP, 2012).

Tajikistan has some of the world's largest hydropower potential. At present, hydropower provides 98% of the country's energy demand, resulting in Tajikistan's considerable low carbon footprint.[9] Energy access throughout the country varies and is especially low and unreliable in mountainous regions, which cover over 70% of the territory. Despite abundant water resources, more than 40% of Tajikistan's population has no access to safe drinking water, and in many rural areas the provision of drinking water remains an acute problem.

Electricity shortages cause irregular water pumping and lead to poor-quality drinking water in many urban and rural areas; such irregular pumping leads to water stagnation in reservoirs, which deteriorates its quality. In order to reduce the number of people who lack access to safe drinking water by half, it is estimated the country will need about US$1 billion by 2015 (UNDP, 2012). The lack of energy as well as an increasingly unstable supply translate into irrigation water shortages, and thus directly cause a decline in economic activity and incomes.

The state of the environment in Tajikistan is depressing; in 2006, the cost of environmental degradation was estimated at almost 10% of the country's GDP, with land degradation contributing to 3.8% of GDP (Olcott, 2012). Agricultural land in Tajikistan amounts to just over 5% of its territory, with large parts affected by erosion and salinisation, both of which are irreversible.

It is estimated that the quality of 97% of the arable land has severely declined over the past 15 years. Outdated agricultural practices and poor land management, along with the overuse of forests for fuel, are the main reasons behind land degradation. The conditions are worse in mountain regions: soil erosion of rain-fed farmlands, degradation of pastures, degradation of forests and bushes with a subsequent loss of biodiversity, irrigation-related degradation and degradation owing to natural disasters (mudflows and floods). In most aspects, land degradation here is similar to in other countries in Central Asia, though it is far more acute in Tajikistan (Table 2).

In light of climate change, it is expected that irrigated agriculture will be the most threatened sector as reduced water runoff is expected to put dramatic stress on Tajikistan's land resources. By 2100, crop yields in some regions of the country will have fallen by 30%, causing changes in crop and forage quality and the spread of pests and diseases (World Bank, 2013).

[8] Also known as the Planning Commission of Pakistan.

[9] Yet, there are concerns using the term 'clean'; limited or no access to energy resources forces the rural population to cut trees, which is the natural sink for CO2 emissions.

Table 2: Erosion in Central Asia

Country	Type of erosion	1990-1999		2000-2005	
		Mln ha	% of total area	Mln ha	% of total area
Kazakhstan	Water	1.44	0.52	1.05	0.38
	Wind	1.47	0.53	0.6	0.22
Kyrgyzstan	Wind, water and pasturable erosion	5.4	27	5.7	28.5
Uzbekistan	Water	n.a.	n.a.	0.135	3.14
	Wind	n.a.	n.a.	0.365	8.48
Tajikistan	Water	8.3	58	10.3	72
	Wind	3.7	26	3.7	26

Source: Adapted from Olcott (2012).

Table 3: Size of perennial plants by type in Tajikistan

Type	2004	2005	2006	2007	2008	2009	2010	2011
Forests, ha	296,347	295,867	292,424	292,118	291,979	292,306	294,449	291,548
Shrubs, ha	252,420	267,805	271,784	272,103	271,051	272,346	269,981	273,601
Other perennial plants, ha	102,628	101,136	103,136	105,571	105,104	109,671	120,662	126,417
Total, ha	651,395	665,307	667,344	669,792	668,134	674,323	685,092	691,566

Source: Adapted from NAMA (2014).

Coupled with other barriers, such as lack of finance, technical capacities and obsolete infrastructure, climate change will seriously challenge food security and sustainable economic development. It is known that irrigated agriculture depends completely on water availability, which will experience a substantial decline in the long term. Estimates show that, in the next 20 years, the flow of main rivers, such as the Amudarya and the Syrdarya, will be most likely reduced by 20% to 30%, causing economic decline throughout the whole Central Asia region (IPCC, 2007).

Forests in Tajikistan have five main functions: recreational, agricultural, water conservation, soil erosion control and fuelwood. Official statistics indicate that roughly 3% of the country's territory is still covered with forests, and almost all of them are severely degraded (NAMA, 2014). Direct costs of deforestation include losses for non-timber products, fuelwood, tourism and recreation; indirect costs of deforestation include the loss of watershed protection. Since independence in 1947, forest areas have been reduced by 27%.

In 2006, the World Bank estimated that the total cost of deforestation was 0.2% of GDP (Olcott, 2012). Main causes of deforestation in Tajikistan are anthropogenic and include illegal logging of trees and shrubs primarily for use as fuelwood and timber; conversion of forestry areas to agricultural use with further felling of trees and shrubs; illegal seizure of land; and unsustainable management practices including excessive cattle grazing. Table 3 indicates dynamics in the size of perennial plants.

5.4 Natural capital endowment and drivers of change in Kenya

Scarce and poorly distributed water resources characterise Kenyan ASALs. Water sources include few permanent rivers and seasonal streams, which flow only during the wet season and remain dry for the rest of the year. All this contributes to poor access to water sources in the drylands, where ownership of water resources is usually vested in the local community rather than the household.

Vegetation varies widely: grass and scrubland dominate the lowlands; woody savannah is found in wetter, semi-arid areas; montane forests, fed from the fog in the atmosphere, cover higher grounds like the Marsabit, Kulal and Huri mountains.

Land is another asset in ASALs on which many livelihoods depend. Pastoralist areas in most of north and north-east Kenya fall under the Trust Lands Act, implying the land is held in trust for the community by the county councils. These grazing lands are often encroached on by settlers, who sometimes erect fences there. Furthermore, irrigation

has converted some otherwise dry areas into more productive cropland, which inhibits the mobility of pastoralists and grazing. In some areas, common land is increasingly being converted to private property, encouraging crop farming, which also uses the best land for grazing.

Several mining and quarrying activities also take place in ASALs. This includes sand harvesting, gravel digging, prospecting for gold and precious stones and marble quarrying. There are also ongoing mineral exploitation activities (e.g. coal, titanium, limestone, soda ash and oil and natural gas). These activities provide substantial revenue to the national economy in addition to opportunities for employment. However, if not set out well, mining and quarrying can have negative effects on the environment as they may lower water tables and cause pollution.

Socioecological systems in both the Kenyan ASALs and the Horn of Africa are undergoing transformations mediated by extreme climate events, like drought, floods and socio-cultural changes. Extensive land degradation and unsustainable management/land-use practices have weakened traditional and local institutions. Increased conflict based on perceived marginalisation and natural resource conflicts all require new tools and approaches if the root causes of these problems are to be addressed.

Low levels of human development and high levels of poverty increase vulnerability in Kenyan ASALs; climate shocks and stresses normally have greater consequences here, especially drought. Other socioeconomic consequences of climate change in ASALs include changing demographic patterns, as people settle in towns as a result of the loss of livestock-based livelihoods and insecurity and conflicts arising from competition over scarce resources.

Climate change has also been blamed for negative ecological impacts in ASALs. Rich in flora and fauna, ASALs have suffered a loss in biodiversity, as seen in the loss of certain species and dwindling numbers of other indigenous species. While this cannot be blamed entirely on climate change, it has been noted that climate change impacts are compounded by practices such as deforestation and encroachment into fragile ecosystems, which result in local environmental degradation. Ecosystem management approaches need to be integrated into climate change adaptation measures in order to enhance the resilience of local communities through an improved and sustainable flow of ecosystem services.

5.5 Natural capital endowment and drivers of change in Tanzania

Tanzanian ASALs are largely characterised by grasslands, dense thickets, brachystegia (miombo) woodlands and seasonally inundated grasslands (Kisanga, 2002). Brachystegia woodlands may have developed during earlier periods when the field layer was sparse because of grazing. Secondary forests are believed to have developed mainly where fires were not frequent, particularly at higher altitudes.

Most of this natural vegetation has been degraded as a result of human activities (Sechambo et al., 1999). Major causes include forest clearing for agriculture expansion, especially shifting cultivation; fires to stimulate grazing pastures; human settlements; and charcoal mining and making. The grasslands are still characterised by early succession species and will probably remain open grasslands as long as frequent burning continues (ibid.).

Semi-arid savannahs in northern Tanzania have a lower density of vegetation and fewer species of fruit trees (Copeland, 2009). The plants that have the most abundant potential for animal consumption are seasonally available acacia seeds and pods, *Adansonia digitata* (baobab) leaves and flowers, grass seeds and the underground parts of marsh plants.

While regional-level population growth for Tanzanian ASALs is close to the national average, more significant differences are found at the district level. Urban districts in semi-arid areas, which include such centres as Singida, Shinyanga and Morogoro, consistently have the highest growth rates (3.7% to 4.6 %), suggesting a rural to urban migration.

At the national level, the proportion of people living in rural areas has also declined, from 94% of the total population in 1967 to 87% in 1978, and down to 80% at the time of the 1988 population census. District figures indicate that people and growth are more concentrated in areas that have better agricultural potential and infrastructure. Population densities in both central and north-east semi-arid zones are 20 to 50 persons/km^2 with some important exceptions (Morris et al., 2001); there are much higher population densities in the urban districts (over 100 persons/km^2) and also in areas towards Lake Victoria, including Maswa district in Simiyu region (104 persons/km^2).

Purely pastoral systems are the principal means of livelihood in Tanzanian ASALs, where climatic and soil conditions do not favour sufficient food production. Agriculture in Tanzanian ASALs occurs mainly in agro-pastoral farming systems, especially in the Sukumaland (Morris et al., 2001) and Singida and Mara regions.

Common crops grown there include sorghum, millet, maize, cotton, oilseeds and rice (Morris et al., 2001). Nevertheless, pastoralism is complemented by crop production, and there are

synergistic relations between the two livelihood strategies: livestock is regularly used in agricultural activities.

A high degree of complementarity is achieved both in the interactions between livestock and cropping and in the differentiated land use according to soil patterns and soil moisture regimes. For instance, after the harvest, crop residues provide feed to support livestock keeping and manure from that livestock is then used to improve soil productivity, thus increasing yield. Additionally, there are opportunities for policy intervention to support better integration of livestock in cropping systems.

The main problem for these systems is low, unreliable rainfall, which results in the high risk of crop failure.Another problem is the relatively high pressure from both human and livestock populations, which has led to the over-cultivation of cropland and the overgrazing of rangeland (Mwalyosi, 1992; Shem et al., 2005). In turn, both phenomena have led to the exhaustion of already low fertility status lands and/or severe soil erosion. Soil exhaustion and sheet erosion have seriously affected crop yields (Kisanga, 2002). The process has generally resulted in an out-migration of many agro-pastoralists from the semi-arid areas of Sukumaland into the southern regions of Mbeya, Morogoro and Lindi.

Other economic activities in ASALs include wildlife conservation, which also overlies policy framework. As a result, wildlife conservation and land tenure policies have the greatest impact on other land uses, including pastoralism, through land tenure decisions that are usually made at the national level. These in turn have strong implications for ecosystem integrity and sustainability, since most of the pastoral communities tend to perceive conservation policies as unfavourable to pastoral activities.

According to Mwalyosi (1992), the lack of effective land-use planning in semi-arid areas has also largely contributed to the present state of affairs. Pastoralism in Tanzania has suffered from the effects of settlement expansion and state encroachment in the form of establishing national parks and game reserves, something that has often led to the subsequent exclusion of pastoralists (Sørensen, 2006).

In addition to conservation policies, the exclusion of pastoralists in ASALs is compounded by investment policies, especially in areas with heavy chunks of mineral endowment. Over the past decade in Tanzania, the mining sector has been given priority. Substantial investments, largely from international mining companies, have been observed in the mining sector. Despite considerable progress, there have been continuous struggles between communities and mines, affecting labour relations and security. These struggles owe largely to the displacement of people and very low compensation levels, both of which have left many dissatisfied.

Some parts of the Shinyanga region vividly exemplify this situation. Apart from environmental challenges related to large- and small-scale artisan miners (e.g. land cover charges), there have also been incidences of land amalgamation and turning pastoralist systems into mining production systems. Good governance at the mines must be established as the mines operate within prevailing neighbourhoods, as the next section discusses.

6. Key issues and policy implications: global perspective

Grape farmer in Pakistan:

Mixed impacts from socio-ecological systems have forced policy- and decision-makers to search for alternative policy interventions to address the livelihood needs of the poor as well as contribute to the adaptation to climate change impacts and the sustainability of the resource base (Shiferaw and Bantilan, 2004).

Odhiambo (2013) indicates that inadequate natural resource endowment, low investments and fragile ecosystems have worked over time to eventually characterise ASALs with disasters and food aid. Odhiambo also adds that both climatic and non-climatic factors are responsible for the underdevelopment of ASALs. In most cases, an unclear institutional framework for development interventions in ASALs has compounded the severity of climatic stresses on community livelihoods and the environment (ibid.).

In addition, Odhiambo (2013) indicates that the underdevelopment of ASALs is reflected through the under-utilisation of available land resources. For instance, according to Odhiambo, about 84% of Kenya's total ASAL landmass remains largely underexploited; out of about 24 million ha that can be used for livestock production, only 50% of the land's carrying capacity is currently being exploited. Additionally, there are 9.2 million ha in ASALs that have the potential for crop production if irrigated (ibid.).

Furthermore, though pastoralism is cited as a key livelihood system for ASAL communities, Shem (2010) indicates it is not well received in policies and is considered an unsustainable livelihood strategy, partly because of its mobile nature. In most cases, this perception has continuously influenced policy to favour farmers' expansion of their fields in order to make the country self-sufficient in food, while pastoralists have been forced to reduce livestock numbers to prevent overgrazing and soil erosion (Benjaminsen et al., 2009; Ndagala, 1990). Therefore, according to Odhiambo (2013), substantial investments are required to help ASAL communities effectively utilise available opportunities and improve resource productivity.

Benjaminsen et al. (2009) report that another factor contributing to pastoralism's ill-reception as a viable livelihood option is lack of power and voice in policy-making debates. According to Shem (2010), landraces, the genetic potential of indigenous livestock breeds and security of tenure among pastoral communities are not streamlined well in the National Land Policy (1995), the National Livestock Policy (2006) and the Village Land Act of 1999, respectively.

Policy intervention towards increasing conservation areas has also been a challenge to livelihoods and natural resource management in ASALs. The need for conservation and increasing protected areas has been reflected in some policies and legislation since the late 1990s. These documents include the 1998 Forest Policy, the 2002 Forest Act, the 2004 Environmental Management Act, the 1998 Wildlife Policy and the 2009 Wildlife Act.

Improvement of natural resource productivity through natural resource management and ecosystem services has been given priority in the most recent policy framework. PES is one option that could be considered a viable policy intervention to reward people (Fabricius et al., 2008). Recommendations for PES also seek to encourage land managers rather than to legally outlaw their behaviour.

Recent arguments for integrating PES into climate change adaptation strategy to address poverty and improve the conservation of natural resources distinguish PES from other incentive-based approaches. This is in part because of the unique contract PES has between the involved parties (i.e. the person using the ecosystem service and the person supplying it (Fabricius et al., 2008)). Even if the potential for investment in ASALs is likely to be small, if these arrangements work the successful implementation of PES will improve the poor's well-being and can be used as a compensation scheme for foregone alternative land uses that could be degrading marginal land-based resources (ibid.).

Despite this positive notion, the practicality of PES still faces many barriers (Fabricius et al., 2008), which include inadequate policies that link strategies for addressing climate change adaptation, poverty and ecosystem services to other sectors that deal with issues of social welfare, health, land affairs, energy, economic development, rural development, etc.

High transformation of ecosystems across scales, especially in Africa, will also hamper this new policy framework. Similarly, in Pakistan and other parts of Asia, demographic growth, rapid urbanisation, industrialisation and agricultural expansion will hinder effective implementation of strategies that can balance economic development with natural resource sustainability.

It is also important to note that, for attaining ecosystem-based adaptation and ecosystem services, there will be a need to put other regulatory mechanisms in place as a way to harmonise multiplier effects that are likely to happen. The IPCC (2014a) warns that the widespread transformation of ecosystems in order to devise mechanisms for adaptation and mitigation to climate change impacts (e.g. the conversion of natural forest land into fast-growing tree species for carbon sequestration) will marginalise the capacity of ecosystems to withstand shock from the changing climate.

The sustainability of ecosystem-based adaptation options will also depend on the inclusiveness of local communities and their indigenous knowledge, as well as a holistic view of the community and the environment. Local community engagement is largely based on the fact that local people have experience responding to environmental and ecological changes (IPCC, 2014b). Utilising opportunities associated with the conservation of natural and biodiversity resources will also strengthened sustainability.

Some immediate opportunities include the introduction of PES projects, such as Reduced Emissions from Deforestation and Forest Degradation (REDD). However, there is little explanation as to how to successfully implement PES-based adaptation efforts. Along with varied policy and legal framework across scales, power relations among key stakeholders and communities could also hamper the success of PES-based adaptation efforts. Gender inequalities, insecurity of tenure rights, unequal access to natural resources and weak decision-making on natural resource management are some of immediate barriers that could affect the effective implementation of ecosystem-based payments (IPCC, 2014b).

Melick and Eriksen, and Lind, all argue that, if not planned well, the implementation of PES projects created to tap into opportunities associated with conservation efforts could also stimulate conflict over resources and property rights (as cited in IPCC, 2014b). In addition to marginalising conservation efforts, poorly planned PES projects can place communities in conflict with conservationists and governments, resulting in newly created poverty and constraints on livelihoods, which in turn will increase vulnerability to climate change impact (Deng, 2010; IPCC, 2014b; Nigel, 2009).

In order to promote conservation and eventually tap into opportunities resulting from PES, disparities and trade imbalances will need to be addressed as well as isolation from decision-making, gender inequalities and culturally constructed injustice (IPCC, 2014b; OECD, 2013). Therefore, benefits of ecosystem-based adaptation efforts will need to have a pro-poor strategy that addresses tenure and property rights, gender interests and effective community engagement (IPCC, 2014b).

Other policy barriers that hinder the attainment of community resilience include low enforcement of policy actions, poor coordination of existing environmental agreements, complications turning policy into

Karakul Lake, Tajikistan

© Timur Mustaev

practice, concentration of scaling-up efforts on few localised projects, poor monitoring and problematic data and information-sharing (Fabricius et al., 2008).

In addition, Fabricius et al. (2008) recognise another issue hindering community resilience: the gap between the biophysical units that need to be managed and the people or institutions available to manage them. Last but not least, Fabricius et al. (2008) indicate that poor supervision or management of resources in communal areas also deters the attainment of community resilience.

While all livelihood systems are partly affected by the new policy and legal framework, lack of clear tenure rights among pastoral communities has provided a loophole for conservation policy to marginalise pastoral communities in Tanzania (Shem, 2010). For instance, it is obvious that land for pastoral activities has been reduced tremendously since pre-colonial times, when pastoral groups were free to move from Tanzania and Kenya in order to respond to environmental stresses and utilise variable climatic trends (Rowlinson et al., 2008; Shem, 2010).

Given the noticeable challenges that affect livelihood systems and sustainable natural resource management, Rowlinson et al. (2008) recommend policy interventions that would enhance resilience in semi-arid areas. According to these authors and Nori et al. (2008), implementing strategies that help livestock keepers build strong institutions to harness adaptation opportunities can enhance resilience in semi-arid areas. This is the case with the Meru Goat Breeders Association in Kenya and self-help groups in India, where poor households can access credit, animal health care and knowledge services as well as social capital that comes from group membership.

Other strategies recommended for the improvement of policy interventions include creating and intensifying learning opportunities, broadening the set of information and knowledge available to farmers and supporting local innovation. Farmer and livestock field schools are new approaches for the training of trainers and farmers and/or livestock keepers through the real practice of farming and livestock keeping. The Overseas Development Institute's Agricultural Research and Extension Network (2005) is an example of how this can be done. The third intervention Rowlinson et al. (2008) recommend is to engage livestock keepers in the co-generation of knowledge, devising appropriate adaptation options that can particularly be adopted by small-scale, relatively poor livestock keepers.

Fabricius et al. (2008) argue that policy interventions towards community-based natural resource management (CBNRM) will also contribute to sustainable natural resource management. This approach addresses some

challenges related to tenure, access and user rights as well as providing chances for adjacent communities to participate in conservation processes and make some money in the process (ibid.).

In some parts of Tanzania, participatory forest management through joint forest management and community-based forest management (CBFM) and wildlife management through wildlife management areas (WMAs) have contributed to a reduction in conflicting interests and ownership issues between adjacent communities and the government. Tangible results have been evident in CBFM approaches, where state dominance in decision-making is relatively low and communities are likely to participate effectively in management and benefit sharing.

Fabricius et al. (2004) indicate that CBNRM in Tanzania will result in new policies and legislation that will allow communities and

farming, integrated pest management, participatory sustainable land management approaches and agroforestry (Anderson et al., 2004; Fabricius et al., 2008; Reij & Steeds, 2003).

Policy interventions should also focus on land reforms as an incentive to land investments, address land degradation and stimulate socioeconomic development and sustainable management of land resources. This is in part because there is widespread insecurity about land tenure issues in African ASALs. This can partly be pinned on past policies that have failed to give indigenous and customary occupancy the same status as private property tenure.

The most affected resources have been those owned in common. According to Fabricius et al. (2008), higher-valued resources are often taken from locals and given to investors and other people outside the community, which deprives marginalised groups to enjoy the benefits accrued from natural resources. These benefits can be in terms of monetary value, organisational capacity and local governance.

Other benefits associated with CBNRM include multiple livelihood options and increased resilience; employment opportunities; enhancement of the resource base; and thus a break from the vicious circle of poverty and natural resource dependence and degradation (Bowen et al., 2012; Fabricius et al., 2008). Therefore, if CBNRM is planned well and lessons are scaled up, engaging communities in natural resource management could yield positive results and contribute to human and ecosystem resilience in ASALs.

Pastoralism as an adaptive response has also been cited as a viable strategy to enhance resilience in ASALs. This is particularly recommended given

community members – especially the poor – from protection against social transformation and the commoditisation of land.

Although various efforts are being applied to deal with unequal access to land in African ASALs, there is still progress to be made when it comes to customary tenure in terms of both social class and gender (Campbell et al., 2003; Cousins, 2007; Lahiff, 2003) – hence the dire need for policy reform to ensure equal access to land and socioeconomic development.

Pilot climate change adaptation projects are also recommended as learning platforms and as avenues to build local community resilience. However, current support for community-based projects is largely implemented by non-governmental organisations (Fabricius et al., 2008).

Stakeholder engagement platforms could also form a basis for learning and building on indigenous

that, in African ASALs, mobile pastoralism is a modified form of land use that has evolved with the changing social and ecological systems.

Considering that indigenous people change with their environment, it is of utmost importance that external interventions are an addition to existing knowledge and practices. As Fabricius et al. (2008) note, building on existing indigenous knowledge and practices has been cited as a key success factor in several different literatures. Therefore, it would be wise for policies to respect mobile pastoral strategies (ibid.).

Agro-ecological approaches are also seen as viable options for addressing poor production and food insecurity in semi-arid zones, providing avenues to mitigate negative impacts of land-use change. Good examples approaches include conservation agriculture, eco-agriculture, organic

knowledge and experiences, with scientific knowledge as a step towards the development of locally owned and accepted adaptation interventions (Mbilinyi et al., 2013). Traditional knowledge has also been considered relevant for policy formulation and decision-making processes, especially in inclusive development (ibid.).

7. Conclusion and recommendations for Deep Dives

Previous studies on ASALs have generated important knowledge on natural resource endowment and management, and key drivers underlying natural resource degradation, livelihood systems and climate change impacts. Past studies have also analysed the interrelationship between the climatic environment, structural processes and the existence of poverty.

Literature also indicates key barriers and patterns of development fundamental to the attainment of sustainable natural resource management and development. The most mentioned barrier in literature is tenure, which is pinpointed as a factor that hinders resilience among ASAL communities, especially the poor (Fabricius et al., 2008). Additionally, existing literature confirms that ecosystem services can contribute to the sustainability of natural and social systems, and also help alleviate poverty. Nevertheless, there are still key knowledge gaps that need to be fulfilled by research.

In-depth analysis of community and ecosystem interdependences in ASALs is required to inform policy. Key issues to be addressed include the viability of ecosystem services in addressing poverty, key drivers of ecosystem change in ASALs and possible remedial measures to improve conservation and livelihood activities. The analysis of the drivers of ecosystem change must pay great attention to structural processes, such as the insecurity of natural resource tenure and how it underlies natural resource degradation in ASALs. It is also wise to analyse how ecosystem change affects livelihood systems in ASALs and establish patterns of winners and losers (Fabricius et al., 2008) as well as consequences for the poor. Specifically, this thematic review suggests the following questions be addressed in the course of the implementation of the project.

7.1 Burkina Faso and Senegal

The literature review in the foregoing paragraphs shows that populations in both Burkina Faso and Senegal are heavily dependent on natural resources and climate-sensitive sectors, such as agriculture and livestock-keeping; hence drought cycles, as well as temperature increases, observed in these countries will have considerable impacts, especially on the productivity of the agriculture and livestock sectors.

It has also been established in Senegal and Burkina Faso, the degradation of natural capital owes not just to the adverse effects of climatic deterioration and temperature increases; insufficient financial and technological resources, low response capacity of stakeholders to climate hazards and inappropriate political orientations also affect natural resources in these countries.

Beyond sectors closely related to natural resources, the degradation of natural capital has consequences that also affect social capital, territorial dynamics and social relations. For example, in Burkina Faso the ecosystem degradation of agricultural land has spurred migration from drylands to the most fertile areas, which has resulted in an exacerbation of social conflicts between migrants and indigenous communities.

An increase in conflicts between livestock keepers and crop farmers has been observed because of the uncertainty of pastoral activity. Affected by the lack of adequate policies and infrastructure, and the gradual reduction of grazing land and access to resources such as grazing areas and water sources, livestock keepers are forced to move closer to fertile land and therefore closer to farmland. In this regard, the following areas are recommended for further research:

- How can we deepen our understanding, and that of policy-makers, of the threats and opportunities that both the Burkina Faso and Senegal economies face in relation to climate change-related migration?
- Is migration a form of adaptation, or is it an indicator of the limits of adaptation to climate change? The empirical situation in these selected countries needs to be assessed so as to show migration's potential as a climate-risk management strategy.
- Sahelian West Africa is renowned for locally produced water management and climate-smart agricultural strategies and technologies. How much of these technologies still exist? How can they be scaled up/harnessed to address expected challenges of climate change?

- What approach(es) of governance and natural resource management are best suited to address the current Sahelian context?

7.2 Pakistan

Pakistan's economy is highly dependent on a sustainable supply of land, water and forests. The decreasing availability of water for irrigation will result in food insecurity and poverty in both rural and urban areas. In this regard, the conservation of water resources through the protection of a watershed will enhance water flow, including dams for hydroelectricity and irrigation. The northern areas of Pakistan, which also receive heavier annual precipitation, are generally well endowed with dense forests and are rich in minerals.

Nevertheless, the adverse effects of land degradation include the deterioration of dryland ecosystems through intensive flooding, biodiversity loss, decline in land productivity, soil erosion and soil nutrient depletion. The situation is worsened by water shortages and droughts. With climate change, water availability per capita is predicted to decline, thus affecting poor people in both urban and rural areas.

Pakistan has one of the highest rural-to-urban migration rates in South Asia, indicating a shift in livelihood patterns. While urban incomes may not be entirely natural resource-dependent, urbanisation does exert pressure on natural resources by creating demand for water, food and deforestation for housing and infrastructure development.

On the other hand, ownership and tenure rights have affected land use and management of the forestry sector. The traditional system of communal land management was abolished in the 1970s and state ownership of uncultivated land was introduced. Some people claim this state ownership policy has triggered land degradation, as government control over land is weak and lacks ownership or tenure rights.

The following specific issues are recommended for further research:

- How can we deepen our understanding, and that of policy-makers, of the threats and opportunities the Pakistani economy faces in relation to climate change?
- Is migration a form of adaptation, or is it an indicator of the limits of adaptation to climate change and other socioeconomic impacts? Who migrates? Why and how? The empirical situation in Pakistani ASALs needs to be assessed so as to show migration's potential as a climate-risk management strategy.
- What are people's adaptive and coping strategies for natural resource degradation and climate change?

7.3 Tajikistan

Of the six PRISE countries, Tajikistan is the richest in terms of water resources. It is also the country with the largest hydropower potential. Currently, it provides the majority of the country's energy demands, but access to energy varies and is low and unreliable in mountainous regions, which make up 70% of the country. The unreliable energy supply has affected water supply, which in turn has caused a decline in economic activities and incomes.

Therefore, the following areas are recommended for further research:

- How can we deepen our understanding of the place of ecosystem services in the diversification of livelihoods? What are their dynamics in response to prevailing drivers? What is their viability and what are their trade-offs between livelihood systems?
- How can we generate knowledge on tenure issues, especially as an incentive for natural resource management in the upstream and PES, in order to better inform policy for local-level adaptation projects?

7.4 Kenya

Agriculture, livestock-keeping and mining are the main economic activities being practised in Kenyan ASALs; however, farming activities, specifically irrigation farming (which has proven useful for some ASALs communities), have inhibited pastoralists, causing conflicts between farmers and pastoralists. Mining activities, on the other hand, have been blamed for causing pollution and lowering water tables. Further exacerbating the situation are extreme climate events, such as droughts and floods, which communities are unable to easily cope with owing to low levels of human development and high levels of poverty. As a consequence, some ASAL communities have begun migrating to urban areas in search of another livelihood.

Thus, it is vital to further research and document the following:

- As people settle in towns, owing to the loss of livestock-based livelihoods in ASALs, how much of this current urbanisation is a result of climate change?
- What changing demographic patterns in ASALs owe to insecurity and conflicts arising from competition for scarce resources?

7.5 Tanzania

The reviewed literature establishes that purely pastoral systems are the principal means of livelihood in ASALs. Pastoralists have used Tanzanian ASALs for millennia; however, wildlife conservation policies and other factors have constrained the sustainability of pastoralism in ASALs.

Other challenges emanate from investment policies, especially recent growing investment in the mining sector, which has compromised adjacent communities through relocation and inappropriate compensation. This has resulted in the marginalisation of community livelihoods, the change of livelihood strategies and civil unrest among mining companies and adjacent communities.

Given the noticeable challenges that affect livelihood systems and sustainable natural resource management in ASALs, some policy interventions that would potentially enhance resilience in these areas are recommended, as follows:

Issues that need to be addressed in the agriculture sector include:

- The establishment of crop insurance schemes using weather insurance indices;
- The establishment of credit facilities such as savings and credit cooperatives and non-restrictive agricultural loans from banks;
- Investment in research and development (e.g. breeding and dissemination of crop varieties);
- Incorporation of indigenous/traditional/local knowledge on adaptation with modern/scientific knowledge and policy formulation debates (e.g. integration of the traditional knowledge of food preservation and rainfall forecasting/prediction with modern knowledge).

Implementing strategies that support livestock keepers to cope with and adapt to climate change impacts, in both the short and the long terms, can enhance resilience in the livestock sector.

Recommended strategies include:

- The promotion of self-help groups through which poor households can access credit, animal health care and knowledge services as well as the social capital that comes from group membership;
- The improvement of policy interventions that create and intensify learning opportunities, broaden the information and knowledge base available to farmers and support local innovation;
- The creation of stakeholder engagement platforms as bases for learning and building synergies between local experience and knowledge, and scientific knowledge;
- The urgent need for policy reviews and harmonisation to address policy-related barriers for the attainment of community resilience among pastoralists;
- The need to address the lack of timely and accurate information and/or data, and scale mismatches between the biophysical units of ecosystem management and the corresponding social and administrative units affecting successful implementation;
- Finally, the need to address the issue of the poor management of common-pool resources, especially grazing lands in communal areas.

Adaptation measures in the wildlife sector that have been identified and recommended include:

- The enhancement of wildlife extension services and assistance for rural communities in managing wildlife resources;
- The harmonisation of wildlife policies with legislation and the Land Act, Forest Act, the Tourism Act, the Local Government Act and the Local Government Reform Programme as well as other laws of the land so as to minimise resource-use conflicts;
- The promotion of an integrated approach to natural resource management inherent in WMAs to ensure optimal benefits and cost effectiveness.

In the mining sector, compensation for loss of land resources and damages to livelihoods was seen as a major element in finding a resolution; however, negotiations for compensation thus far have involved rights holders who are diverse in their interests and whose negotiation skills have often not matched those of large-scale miners. Ways to enhance the capacity of small-scale miners and local communities to negotiate for their rights and provide them with the opportunity to develop and become more substantial players in the mining industry need to be discovered and internalised.

References

Abel, N.O.J. and Blaikie, P.M. (1990) 'Land Degradation, Stocking Rates and Conservation Policies in the Communal Rangelands of Botswana and Zimbabwe'. Pastoral Development Network Paper 29a. London: ODI. http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/5359.pdf

Agricultural Research and Extension Network (2005) 'Introducing a Farmers' Livestock School Training. Approach into the National Extension System in Vietnam'. Network Paper 144. London: ODI. http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/5170.pdf

Anderson, A., Bryceson, D. and Campbell, B. (2004) 'Chance, Change and Choice in Africa's Drylands: A New Perspective on Policy Priorities in the Drylands of Africa'. Policy Brief. Bogor: CIFOR.

Anwar, T., Qureshi, S.K and Ali, H. (2004) 'Landlessness and Rural Poverty in Pakistan'. *Pakistan Development Review* 43: 855-874. http://www.pide.org.pk/pdf/PDR/2004/4/PartII/Talat%20Anwar.pdf

Aronson, J., Blignaut, J.N., Milton, S.J. and Clewell, A.F. (2006) 'Natural Capital: The Limiting Factor'. *Ecological Engineering* 28: 1-5. http://www.rncalliance.org/epages/rncalliance.sf/en_AU/?ObjectPath=/Shops/rncalliance/Products/%22Article%20009%22

Aronson, J., Milton, S.J. and Blignaut, J.N. (2007) *Restoring Natural Capital: Science, Business and Practice*. Washington, DC: Society for Ecological Restoration International and Island Press. http://biblio.teluq.ca/LinkClick.aspx?fileticket=ZWYgaFppOxY%3D&tabid=42141&language=fr-CA

Barnett, J. and Adger, W.N. (2007) 'Climate Change, Human Security and Violent Conflict'. *Political Geography* 26: 639-655.

Batana, Y., John, C. and Hervé, J.L.G. (2012) 'Analyse de la Situation : Profil de l'équité et de la pauvreté des enfants et des femmes au Burkina Faso en 2010'. Ouagadougou: UNICEF. http://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/publ/PEP-UNICEF_Sitan_BF.fr.pdf

Benjaminsen, T.A., Maganga, F.P and Abdallah, J.M (2009) 'The Kilosa Killings: Political Ecology of a Farmer-Herder Conflict in Tanzania'. *Development and Change,* 40(3): 423-445. http://www.researchgate.net/publication/230265512_The_Kilosa_Killings_Political_Ecology_of_a_FarmerHerder_Conflict_in_Tanzania

Bhatti, S.I. (2011) 'An Overview of Forests in Pakistan'. http://bympress.com/reading/88-98an-overview-of-forests-in-pakistan-final-A4Ne.html

Birch-Thomsen, T., Frederiksen, P. and Sano, H. (2001) 'A Livelihood Perspective on Natural Resource Management and Environmental Change in Semi-arid Tanzania'. *Economic Geography Journal* 77(1): 41-66. http://sanrem.cals.vt.edu/1048/A%20Livelihood%20Perspective%20on%20NRM.pdf

Bizikova, L. (2012) 'Semi-Arid Areas'. Presented on behalf of Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) Programme during COP18, Doha, 26 November-7 December. http://www.idrc.ca/EN/Documents/CARIAA_COP18_Policy_Semi-arid.pdf

Blaikie, P. and Brookfield, H. (1987) *Land Degradation and Society*. London and New York: Methuen. http://www.amazon.com/Land-Degradation-Society-Development-Studies/dp/0416401503

Boko, M., Niang, A., Nyong, A., Vogel, C., Githeko, M., Mednay, M., Osman-Elasha, B., Tabo, R. and Yanda, P. (2007) 'Africa', in *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. Cambridge and New York: CUP. https://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch9.html

Bowen, A., Cochrane, S. and Fankhauser, S. (2012) 'Climate Change, Adaptation and Economic Growth'. *Climatic Change* 113: 95-106. http://courses.arch.vt.edu/courses/wdunaway/gia5524/bowen12.pdf

Brand, F. (2008) 'Critical Natural Capital Revisited: Ecological Resilience and Sustainable Development'. *Ecological Economics* doi:10.1016/j.ecolecon.2008.09.013. http://www.researchgate.net/publication/222559753_Critical_natural_capital_revisited_Ecological_resilience_and_sustainable_development

Campbell, B.M., Vermeulen, S.J., Mangono, J.J. and Mabugu, R. (2003) 'The Energy Transition in Action: Urban Domestic Fuel Choices in a Changing Zimbabwe'. *Energy Policy* 31: 553-562.

Copeland, S.R (2009) 'Potential Hominin Plant Foods in Northern Tanzania: Semi-arid Savannas Versus Savanna Chimpanzee Sites'. *Journal of Human Evolution* 57: 365-378.

Cousins, B. (2007) 'More Than Socially Embedded: The Distinctive Character of "Communal Tenure" Regimes in South Africa and Its Implications for Land Policy'.

Journal of Agrarian Change 7(3): 281-315.

CSE (Ecological Monitoring Centre) (2010) 'Rapport sur l'état de l'environnement'. Dakar: Ministère de l'Environnement et de la Protection de la Nature. http://apps.unep.org/publications/pmtdocuments/-Rapport%20sur%20l%E2%80%99%C3%A9tat%20de%20l%E2%80%99environnement%20au%20S%C3%A9n%C3%A9gal-2010Rapport_Etat_Envi_2010.pdf

Daly, H. and Farley, J., (2004) *Ecological Economics: Principles and Applications*. Washington, DC: Island Press. http://islandpress.org/ecological-economics-second-edition

Deng, L.B. (2010) 'Livelihood Diversification and Civil War: Dinka Communities in Sudan's Civil War'. *Journal of Eastern African Studies* 4(3): 381-399.

DFID (Department for International Development) (2001) 'Strategy for Research on Renewable Natural Resources'. Technical Report for the DFID's Natural Resources Systems Programme – Semi Arid Systems. London: DFID.

Diagne, M. (2000) 'Vulnérabilité des productions agricoles au changement climatique au Sénégal'. Dakar: Ministère de la Jeunesse, de l'Environnement et de l'Hygiène Publique..

Djiga, H.A. (2009) 'La gouvernance locale à l'épreuve des migrations dues aux changements climatiques : Cas des rapports entre conseils villageois de développement et chefs traditionnels au Burkina Faso dans la gestion des conflits sociaux'. *VertigO* 6, November.

Dullinger, S.A., Gattringer, W., Thuiller, D., Moser, N.E., Zimmermann, A., Guisan, W., Willner, C., Plutznar, M., Leitner, T., Mang, M., Caccianiga, T., Dirnboeck, S., Ertl, A., Fischer, J., Lenior, J.-C. , Svenning, A., Psomas, D.R., Schmatz, U., Silc, P. , Vittoz, K. and Huelber, K. (2012) 'Extinction Debt of High-mountain Plants under Twenty-first Century Climate Change'. *Nature Climate Change* 2: 619-622.

Ehrlich, P.R., Kareiva, P.M., and Daily, G.C. (2012) 'Securing Natural Capital and Expanding Equity to Rescale Civilization'. *Nature* 486(7401): 68-73.

Environment Management Group of the UN (2011) *Global Drylands: A UN System Wide Response.* Gyeongnam: UN.

Eriksen, S. and Lind, J. (2009) 'Adaptation as a Political Process: Adjusting to Drought and Conflict in Kenya's Drylands'. *Environmental Management* 43(5): 817-835.

Eyzaguirre, P.B. and Dennis, E.M. (2007) 'The Impacts of Collective Action and Property Rights on Plant Genetic Resources'. *World Development* 35: 1489-1498.

Fabricius, C., Koch, E., Magome, H. and Turner, S. (eds) (2004). *Rights, Resources and Rural Development: Community-based Natural Resource Management in Southern Africa*. London: Earthscan.

Fabricius, C., Shackleton, C., Mortimore, M. and Bond, I. (2008) 'Situation Analysis of Ecosystem Services and Poverty Alleviation in Arid and Semi-arid Africa'. The Madrid: CEPSA Consortium. http://www.nerc.ac.uk/research/programmes/espa/documents/Final%20Report%20Africa.pdf

FAO (Food and Agriculture Organization) (2000) 'The Elimination of Food Insecurity in the Horn of Africa. A Strategy for Concerted Government and UN Agency Action'. Final Report. Rome: FAO.

FAO (Food and Agriculture Organization) (2010) *Dry Lands, People and Land Use*. Rome: FAO.

FAO (Food and Agriculture Organization) (2011a) 'Indus River Basin', in K. Frenken (ed.) *Irrigation in Southern and Eastern Asia in Figures: AQUASTAT Survey 2011*. Rome: FAO.

FAO (Food and Agriculture Organization) (2011b) *State of the World's Forests*. Rome: FAO.

FAO (Food and Agricultural Organization) (2014) *State of the World's Forests: Enhancing the Socioeconomic Benefits from Forests*. Rome: FAO.

Faruqee, R. (1996) 'Role of Economic Policies in Protecting Environment: The Experience of Pakistan'. *Pakistan Development Review* 35(4): 483-506. http://www.jstor.org/stable/41259978?seq=1#page_scan_tab_contents

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, J.C., Ramankutty, N. and Snyder, P.K. (2005) 'Global Consequences of Land Use'. *Science* 309: 570-574.

Geiser, U. and Steimann, B. (2004) 'State Actors' Livelihoods, Acts of Translation and Forest Sector Reforms in Northwest Pakistan'. *Contemporary South Asia* 13(4): 437-448.

GoP (Government of Pakistan) (2005) 'Medium Term Development Framework (MTDF): An Overview'. Islamabad: Planning Commission.

GoP (Government of Pakistan) (2009) (2007) 'Agricultural Growth: Food, Water and Land', in *Vision 2030*. Islamabad: Planning Commission.

GoP (Government of Pakistan) (2009) 'Draft National Water Policy'. Islamabad: GoP.

GoP (Government of Pakistan) (2010) 'Task Force on Climate Change'. Islamabad: Planning Commission.

GoP (Government of Pakistan) (2012) 'National Climate Change

Policy'. Islamabad: Ministry of Climate Change.

GoP (Government of Pakistan) (2013) 'Economic Survey 2013'. Islamabad: Economic Affairs Division.

GoP (Government of Pakistan) (2014a) 'Annual Plan 2014-15'. Islamabad: Ministry of Planning, Development & Reform.

GoP (Government of Pakistan) (2014b) 'Economic Survey 2014'. Islamabad: Economic Affairs Division.

Government of Kenya (2010) 'National Climate Change Response Strategy'. Nairobi: Ministry of Environment and Mineral Resources.

Guthiga, P. and Newsham, A. (2011) 'Climate Vulnerability and Poverty in Africa'. Nairobi: International Livestock Research Institute.

Hesse, C. and MacGregor, J. (2006) 'Pastoralism: Drylands Invisible Asset? Developing a Framework for Assessing the Value of Pastoralism in East Africa'. Issue Paper 142. London: IIED.

Homer-Dixon, T. (1991) 'On the Threshold: Environmental Changes as Causes of Acute Conflicts'. *International Security* 16(2): 76-116.

Homer-Dixon, T. (1994) 'Environmental Scarcity and Violent Conflicts: Evidence from Cases'. *International Security* 19(1): 5-40.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R.S., Brockhaus, M., L. Verchot, L., Angelsen, A. and Romijn, E. (2012) 'An Assessment of Deforestation and Forest Degradation Drivers in Developing Countries'. *Environmental Research Letters* 7(4): 044009, doi:10.1088/1748-9326/7/4/044009.

Hountondji, Y.-C.H. (2008) 'Dynamique environnementale en zones sahélienne et soudanienne de l'Afrique de l'Ouest : Analyse des modifications et évaluation de la dégradation du couvert végétal'. Doctoral thesis, University of Liège.

IPCC (Intergovernmental Panel on Climate Change) (2007) 'Climate Change Impacts, Adaptation and Vulnerability. Summary for Policy-makers'. Working Group II Contribution to the IPCC Fourth Assessment Report. Cambridge and New York: CUP.

IPCC (Intergovernmental Panel on Climate Change) (2014a) 'Asia', in *Climate Change: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fifth Assessment Report of the IPCC. Cambridge and New York: CUP.

IPCC (Intergovernmental Panel on Climate Change) (2014b) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC* Cambridge and New York: CUP. https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf

Jama, B. and Zeila, A. (2005) *Agroforestry in the Dry lands of Eastern Africa: A Call to Action*. Nairobi: World Agroforestry Centre.

Kajembe, G.C., Mbwilo A.J., Kidunda, R.S. and Nduwamungu, J. (2003) 'Resource Use Conflicts in Usangu Plains, Mbarali District, Tanzania'. *International Journal of Sustainable Development and World Ecology* 10: 333-343.

Kakakhel, S. (2011) 'Stocktaking Report on Sustainable Development in Pakistan: Policies/Actions/Progress/Gaps/Needs'. Unedited draft for Pakistan's National Preparatory Process for UNCSD, Rio de Janeiro, 20-22 June 2012. Islamabad: SDPI. http://www.uncsd2012.org/content/documents/303stocktaking%20report-21%20aug%2023rd.pdf

Kangalawe, R.Y.M. and Lyimo J.G. (2013) 'Climate Change, Adaptive Strategies and Rural Livelihoods in Semi-arid Tanzania'. *Natural Resources* 4: 266-278. www.scirp.org/journal/PaperDownload.aspx?paperID=33833

Khan, R.A. and Mehmood, R.T. (2003) 'Potential and Prospects of Mountain Forests', in S.A. Mufti, S.S. Hussain and A.M. Khan (eds) *Mountains of Pakistan: Protection, Potential and Prospects.* Islamabad: Global Change Impact Studies Centre.

Kisanga, D. (2002) 'Soil and Water Conservation in Tanzania – A Review', in T. Slaymaker and R. Blench (eds) *Rethinking Natural Resource Degradation in Sub-Saharan Africa: Policies to Support Sustainable Soil Fertility Management, Soil and Water Conservation Among Resource-Poor Farmers in Semi-Arid Areas*. Tamale: University of Development Studies. http://www.tanzaniagateway.org/docs/tzlit.pdf

Lahiff, E. (2003) 'Land and Livelihoods: The Politics of Land Reform in Southern Africa'. *IDS Bulletin* 34(3): 54-63.

Lankford, B.A. Merrey, D.J., Cour, J. and Hepworth, N. (2007) 'From Integrated to Expedient: An Adaptive Framework for River Basin Management in Developing Countries'. Research Report 110. Colombo: IWMI.

Lawes, M.J., Eeley, H.A.C., Shackleton, C.M., Leakey, R.R.B., Shackleton, S.E. and du Plessis, P. (2004) 'Domestication Potential of Marula (Sclerocarya birrea subsp. caffra) in South Africa and Namibia. 1. Phenotypic Variation in Fruit Traits'. *Agroforestry Systems* 64: 25-35.

Lugoe, F (2011) 'Aligning and Harmonising the Livestock and Land Policies of Tanzania'. Discussion Paper 35. Dar es Salaam: ESRF.

Lyimo J.G. and Kangalawe, R.Y.M., (2010) 'Vulnerability and Adaptive

Strategies to the Impact of Climate Change and Variability. The Case of Rural Households in Semi-arid Tanzania'. *Environmental Economics* 1(2): 83-94.

Macedo, M.N., DeFries, R.S., Morton, D.C., Stickler, C.M., Galford, G.L. and Shimabukuro, Y.E. (2012) 'Decoupling of Deforestation and Soy Production in the Southern Amazon during the late 2000s'. *Proceedings of the National Academy of Sciences of the United States of America* 109(4): 1341-1346.

Madzwamuse, M., Schuster, B., and Nherera, B. (2007) *The Real Jewels of the Kalahari. Dryland Ecosystem Goods and Services in Kgalagadi South District, Botswana*. Johannesburg: IUCN.

Majule, A.E. (2012) 'Implications of Ecological and Social Characteristics to Community Livelihoods in the Coastal Areas of Tanzania'. *African Journal of Environmental Science and Technology* 6(1): 72-79.

Mattee, A.Z. and Shem M.N. (2006) *Ambivalence and Contradiction – A Review of the Policy Environment in Tanzania in Relation to Pastoralism*. London: IIED.

Mbilinyi, A. (2013) 'Climate Change as a Silent Disaster: Testimonies from Stories by Rural Communities in Tanzania'. Policy Brief. Dar es Salaam: ESRF. http://esrf.or.tz/docs/Climate%20change%20as%20a%20silent%20disaster.pdf

Mbilinyi, A., Ole Saibul, G. and Kazi, V., (2013) 'The Impact of Climate Change to Small-scale Farmers: Voices of Farmers in Village Communities in Tanzania'. Discussion Paper 47. Dar es Salaam: ESRF. http://esrf.or.tz/docs/climate_change.pdf

MEA (Millennium Ecosystem Assessment) (2005a) *Ecosystems and Human Well-being: Desertification Synthesis*. Washington, DC: WRI. http://www.millenniumassessment.org/documents/document.355.aspx.pdf

MEA (Millennium Ecosystem Assessment) (2005b) *Ecosystems and Human Well-being: Policy Responses*. *Findings of the Responses Working Group*. Washington, DC, and London: Island Press and Covelo. www.unep.org/maweb/documents/document.766.aspx.pdf

MECV (Ministry of Environment and Livelihoods) (2010) 'Intégration de la gestion durable de l'environnement et des ressources naturelles aux processus de planification et de budgétisation des actions de développement au Burkina'. Ouagadougou: MECV.

Melick, D. (2010) 'Credibility of REDD and Experiences from Papua New Guinea'. *Conservation Biology* 24(2): 359-361.

Monela, G.C., Chamshama, S.A.O., Mwaipopo, R., and Gamassa, D.M. (2005) A Study on the Social, Economic and Environmental Impacts of Forest Landscape Restoration in Shinyanga Region, Tanzania'. Nairobi: World Conservation Union, Eastern Africa Regional Office. http://cmsdata.iucn.org/downloads/flr_final_report_shinyanga_june2005.pdf

Mongi, H., Majule, A.E. and Lyimo, J.G. (2010) 'Vulnerability and Adaptation of Rain-fed Agriculture to Climate Change and Variability in Semi-arid Tanzania'. *African Journal of Environmental Science and Technology* 4(6): 371-381. http://www.ajol.info/index.php/ajest/article/viewFile/56374/44809

Morris, M., Butterworth, J., Lamboll, R., Lazaro, E., Maganga, F. and Marsland, N. (2001) 'Household Livelihood Strategies in Semi-arid Tanzania: Synthesis of Findings', Annex to DFID Natural Resources Systems Programme Final Technical Report for Research Project R7805. Dar es Salaam: Natural Resources Institute, Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture and Institute of Resource Assessment, University of Dar es Salaam. http://www.nrsp.org.uk/database/documents/730.pdf

Mortimore, M. (1998). *Roots in the African Dust. Sustaining the Sub-Saharan Dry-lands.* Cambridge: Cambridge University Press.

Morton, J.F. (2007) 'The Impact of Climate Change on Smallholder and Subsistence Agriculture'. *Proceedings of the National Academy of Sciences* 104(50): 19680-19685.

Msangi, H.B.A. (1995) 'The Influence of Socio-economic Factors on the Promotion and Adoption of Agroforestry Technologies Based on the Traditional Ngitiri System: A Case Study of Shinyanga, Tanzania'. Masters of Science in Environmental Forestry Dissertation, School of Agricultural and Forest Sciences, University of Wales, Bangor.

Mukhtar, I. and Hannan, A. (2012) 'Constraints on Mangrove Forests and Conservation Projects in Pakistan'. *Journal of Coastal Conservation* 16(1): 51-62.

Mustaeva, N. (2013) 'Climate Change and Challenges to Sustainable Human Development in Tajikistan', in *Human Development in Action: Case Studies from the Sustainable Human Development Course*. Dushanbe: UNDP and CEU.

Mustaeva, N., Wyes, H., Mohr, B. and Kayumov, A. (2015) 'Country Situation Assessment for Tajikistan'. Dushanbe: CAREC.

Mustalahti, I., Bolin, A. and Paavola, J. (2012) 'Can REDD+ Reconcile Local Priorities and Needs with Global Mitigation Benefits? Lessons from Angai Forest, Tanzania'. *Ecology and Society* 17(1): 16.

www.ecologyandsociety.org/vol17/iss1/art16/

Mwalyosi, R.B.B. (1992) 'Land-Use Changes and Resource Degradation in South-West Maasailand, Tanzania'. *Environmental Conservation* 19(2): 145–152.

Mwiturubani, D.A (2010) 'Climate Change and Access to Water Resources in the Lake Victoria Basin'. Monograph 170

NAMA (Nationally Appropriate Mitigation Actions) (2014) 'Carbon Sequestration through Afforestation and Reforestation in Tajikistan'. Dushanbe: DIW econ, CAREC and the Government of Tajikistan.

Ndagala, D. (1990) 'Pastoralists and the State in Tanzania'. *Nomadic People* 25-27: 51-64.

Ngaido, M. (2002) *La politique environnementale du Sénégal (1960-2002).* Dakar: AfDB.

Nigel, J. (2009) 'Livelihoods in a Conflict Setting'. *Norwegian Journal of Geography* 63(1): 23-34.

Niroula, G.S. and Thapa, G.B. (2005) 'Impacts and Causes of Land Fragmentation and Lessons Learned from Land Consolidation in Asia'. *Land Use Policy* 22(4): 358-372.

Nori, M., Taylor, M. and Sensi, A. (2008) *Browsing on Fences: Pastoral Land Rights, Livelihoods and Adaptation to Climate Change*. Rome: International Land Coalition.

O'Brien, K., Pelling, M., Patwardhan, A., Hallegatte, S., Maskrey, A., Oki, T., Oswald-Spring, U., Wilbanks, T. and Yanda, P. (2012) 'Toward a Sustainable and Resilient Future', in C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor and P.M. Midgley (eds) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.* Special Report of Working Groups I and II of the IPCC. Cambridge and New York: CUP. http://www.ipcc.ch/pdf/special-reports/srex/SREX-Chap8_FINAL.pdf

Odhiambo, M.O. (2013) 'The Unrelenting Persistence of Certain Narratives: An Analysis of Changing Policy Narratives about the ASALs in Kenya'. Position Paper for the New Perspectives on Climate Resilient Drylands Development Project. London: IEED. http://pubs.iied.org/pdfs/10081IIED.pdf

OECD (Organisation for Economic Co-operation and Development) (2013) 'OECD Policy Guidance on Integrating Climate Change Adaptation into Development Co-Operation'. Paris: OECD.

Olcott, M.B. (2012) 'Tajikistan's Difficult Development Path'. Washington, DC: Carnegie Endowment for International Peace.

Paavola, J. (2004) 'Livelihoods, Vulnerability and Adaptation to Climate Change in the Morogoro Region, Tanzania'. Working Paper EDM 04-12. Ipswich: CSERGE.

PARC (Pakistan Agricultural Research Council). (2002) 'National Action Programme to Combat Desertification'. Islamabad: PARC, Ministry of Environment, UNEP and UNESCAP.

PASEF (Project for the Improvement and Valuation of Forest Ecosystem Services) (2010) 'Évaluation des conditions et tendances des écosystèmes forestiers et de leurs services au Sénégal'. Dakar: MEPN and CSE.

Pakistan Water Partnership (2014) 'Aide Memoire: Fact Finding Mission and Drought Master Planning Appraisal Mission, April 16-21, 2014: Tharparker Drought'. Islamabad: Pakistan Water Partnership.

Rasul, G., Mahmood, A., Sadiq, A. and Khan, S.I. (2012) 'Vulnerability of the Indus Delta to Climate Change in Pakistan'. *Pakistan Journal of Meteorology* 8(16): 89-107.

Reij, C. and Steeds, D. (2003) *Success Stories in Africa's drylands: Supporting Advocates and Answering Sceptics.* Rome: UNCCD.

Republic of Kenya (2012) 'National Policy for the Sustainable Development of Northern Kenya and Other Arid Lands'. Nairobi: Republic of Kenya.

Reynolds, J.F., Maestre, F.T., Kemp, P.R., Smith, D.M.S. and Lambin, E.F. (2007) 'Natural and Human Dimensions of Land Degradation in Drylands: Causes and Consequences', in J. Canadell, D. Pataki and L. Pitelka (eds) *Terrestrial Ecosystems in a Changing World*. Berlin: Springer.

Robbins, P. (2004). *Political Ecology*. Oxford: Blackwell Publishing.

Robert, E. (2010) 'Les zones pastorales comme solution aux conflits agriculteurs / pasteurs au Burkina Faso: l'Exemple de la zone pastorale de la Doubégué'. *Les Cahiers d'Outre-Mer* 249: 47-71.

Romshoo, S. (2012) 'Indus River Basin: Common Concerns and the Roadmap to Resolution'. New Delhi: Centre for Dialogue and Reconciliation.

Rowlinson, P., Steele, M., and Nefzaoui, A. (2008) 'Livestock and Global Climate Change'. *Proceedings of the Livestock and Global Climate Change Conference*, Hammamet, 17-20 May. http://www.ifad.org/lrkm/events/cops/papers/climate.pdf

Ruthenberg, H. (1980) *Farming Systems in the Tropics*. Oxford: Clarendon Press.

Saeed, A. (2003) 'The Underlying Causes of Deforestation and Forest Degradation in Pakistan'. XII World Forestry Congress, Québec City, 21-28 September.

Safriel, U. and Adeel, Z. (2005) *Drylands Systems*. New York: MEA.

Sambou, B. (2004) 'Evaluation de l'état, de la dynamique et des tendances évolutives de la flore et de la végétation ligneuses dans les domaines soudanien et sub-guinéen au Sénégal'. Doctoral thesis, Cheikh Anta Diop de Dakar University.

Sechambo, F.C., Sosovele, H. and Kisanga, D. (1999) 'Rethinking Natural Resource Degradation in Semi-arid Sub-Saharan Africa: The Case of Semi-arid Tanzania'. London:. http://www.tanzaniagateway.org/docs/tzlit.pdf

Shahbaz, B., Ali, T. and Suleri, A.Q. (2006) 'A Critical Analysis of Forest Policies of Pakistan: Implications for Sustainable Livelihoods'. *Mitigation and Adaptation Strategies for Global Change* 12: 441-453.

Shem, M. (2010) 'Impacts of Government Policies on Pastoralist Livelihoods in the Semi-arid areas of Tanzania'. ICID+18, Fortaleza-Ceará, 16-20 August. http://www.dewpoint.org.uk/Asset%20Library/ICID18/22-SHEM_ICID+18.pdf

Shem, M.N., Mtengeti, E. and Mutayoba, K.S. (2005) 'Development of Livestock Management and Policy Strategies for Pastoralists in Kilosa, Morogoro Region, Tanzania'. Final Report for AICAD.

Shiferaw, B. (2006) 'Poverty and Natural Resource Management in the Semi-Arid Tropics: Revisiting Challenges and Conceptual Issues'. *SAT eJournal* 2(1). http://www.icrisat.org/journal/mpii/v2i1/v2i1poverty.pdf

Shiferaw, B. and Bantilan, C. (2004) 'Agriculture, Rural Poverty and Natural Resource Management in Less Favored Environments: Revisiting Challenges and Conceptual Issues'. *Food, Agriculture & Environment* 2(1): 328-339. http://core.ac.uk/download/pdf/12103284.pdf

Sørensen, C. (2006) 'Study on the Main Policy Issues Impacting on the Livelihoods of Pastoralists and Hunter-gatherers in Tanzania & Mapping of Key Organisations'. Washington, DC: IWGIA.

Suleri, A.Q., Shahbaz, B. and Khwaja, M.Z. (2010) 'Natural Resources: Blessing or Curse'. Working Paper Series 115. Islamabad: SDPI. http://www.sdpi.org/publications/files/Microsoft%20Word%20-%20A115.pdf

Sultani-i-Rome, (2005) 'Forestry in Princely State of Swat and Kalam (North West Pakistan): A Historical Perspective on Norms and Practices'. Berne: NCCR–North South.

Sultan-i-Rome (2013) 'Forests' Governance in a Historic Perspective – The Examples of Swat State and Kalam', in B. Shahbaz, U. Geiser and A. Suleri (eds) (2013) *Forests, Livelihoods and Relation of Powers*. Lahore: Sangemeel Pubs.

Tiendrebeogo, Y. (2013) 'Evolution du couvert végétal dans la province du Boulkiemdé: Cas de la commune de Poa au Burkina Faso'. Mémoire de maîtrise. University of Ouagadougou.

Tiffen, M., Mortimore, M. and Gachuki, F. (1994) *More People, Less Erosion: Environmental Recovery in Kenya.* Chichester: John Wiley and Sons.

Toulmin, C. (1994) 'Combating Desertification: Encouraging Local Action Withing a Global Framework', in H.O. Bergesen and G. Parman (eds) *Green Globe Yearbook of International Co-operation on Environment and Development.* Oxford: Oxford University Press (79-88).

UNDP (UN Development Programme) (2012) 'Key Messages on Sustainable Energy in Tajikistan: Towards Rio+20'. Dushanbe: UNDP.

UNEP (UN Environment Programme) (2007a) *The Global Environment Outlook 4. Environment for Development*. Nairobi: UNEP.

UNEP (UN Environment Programme) (2007b) 'Biodiversity', in *World Environmental Outlook*. Geneva: UNEP.

UNEP (UN Environment Programme) (2009) 'Preliminary Gap Analysis for the Purpose of Facilitating the Discussions on How to Strengthen the Science–Policy Interface'. UNEP Governing Council, 25th Session, Nairobi, 16–20 February.

United Republic of Tanzania (1995) 'National Land Policy'. Dar es Salaam: Ministry of Lands and Human Settlement Development.

United Republic of Tanzania (2006) 'National Livestock Policy'. Dar es Salaam: Ministry of Livestock Development.

Urban, D., Roberts, M.J., Schlenker, W. and Lobell, D. (2012) 'Projected Temperature Changes Indicate Significant Increase in Interannual Variability of U.S. Maize Yields'. *Climatic Change* 112: 525-533.

Urquhart, P. (2007) 'Adaptation to Climate Change: A Case Study Exploring Effective Tools for Integration'. Case Study for the IIED/DBSA South Africa Country Study for User Guide to Tools for Environmental Integration. www.environmental-mainstreaming.org

USAID (US Agency for International Development) (2010) 'Country Profile Property Rights & Resource Governance: Pakistan.' Washington, DC: USAID. http://usaidlandtenure.net/sites/default/files/country-profiles/full-reports/USAID_Land_Tenure_Pakistan_Profile_0.pdf

Wily, L.A. (2006) 'Land Rights Reform and Governance in Africa: How to Make It Work in the 21st Century?' New York: UNDP

Drylands Development Centre & UNDP Oslo Governance Centre.

Wiskerke, W. (2008) 'Towards a Sustainable Biomass Energy Supply for Rural Households in Semi-arid Shinyanga, Tanzania. A Cost/Benefit Analysis'. Utrecht: Utrecht University. http://www.compete-bioafrica.net/publications/publ/2nd_Report/Annex2-2-3-COMPETE-032448-2ndReport-Thesis-Final.pdf

Wong, C.M., Williams, C.E., Pittock, J., Collier, U. and Schelle, P. (2007) 'World's Top 10 Rivers at Risk'. Gland: WWF International. assets.panda.org/downloads/worldstop10riversatriskfinalmarch13.pdf

World Bank (2005) *Improving Gender Outcomes: The Promise for Pakistan*. New Delhi: Environment and Social Sector Development Unit, South Asia, World Bank. http://siteresources.worldbank.org/INTSAREGTOPPOVRED/1337567-1139839558962/20818167/Pakistan-GenderAssessmentReport_final3-03-05.pdf

World Bank (2013) 'Climate Change Overview: Tajikistan'. http://www.worldbank.org/en/country/tajikistan/overview

World Bank (2014) 'Pakistan: Country Development Landscape'. Working Paper no.91700. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/2014/01/20326787/pakistan-country-development-landscape

Millet field after harvest, Sanmatenga Province, Burkina Faso

PRISE
University of Dar es Salaam
Centre for Climate Change Studies
P.O Box 33453
Dar es Salaam
Tanzania

Tel. +255 22 2410500 Ext. 2979

www.cccs.udsm.ac.tz
www.prise.odi.org

Research for climate-resilient futures

This work was carried out under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development (DfID) and the International Development Research Centre (IDRC), Canada. The views expressed in this work are those of the creators and do not necessarily represent those of DfID and IDRC or its Board of Governors.

CARIAA
Collaborative Adaptation Research Initiative in Africa and Asia

UKaid
from the British people

IDRC | CRDI
International Development Research Centre
Centre de recherches pour le développement international

Canada