Chapter 3: The need for resilience in the drylands of Eastern Africa

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3.1 Classification and distribution of drylands

Drylands make up the vast majority of land in Eastern Africa (Figure 3.1). Drylands are characterized by water scarcity, and are defined as lands with an aridity index, the ratio between annual rainfall and annual potential evapotranspiration, of below 0.65. A further distinction in four dryland sub-systems is made into hyper-arid lands with an aridity index below 0.03, arid lands (0.03 – 0.20), semi-arid lands (0.20 – 0.50) and dry sub-humid lands (0.50 – 0.65). The map reveals that the majority of the Eastern Africa territory is classified as dryland. The semi-arid and the arid zone are the largest single dryland systems, followed by the dry sub-humid zone. A small fraction of northern Somalia is classified as hyper-arid.

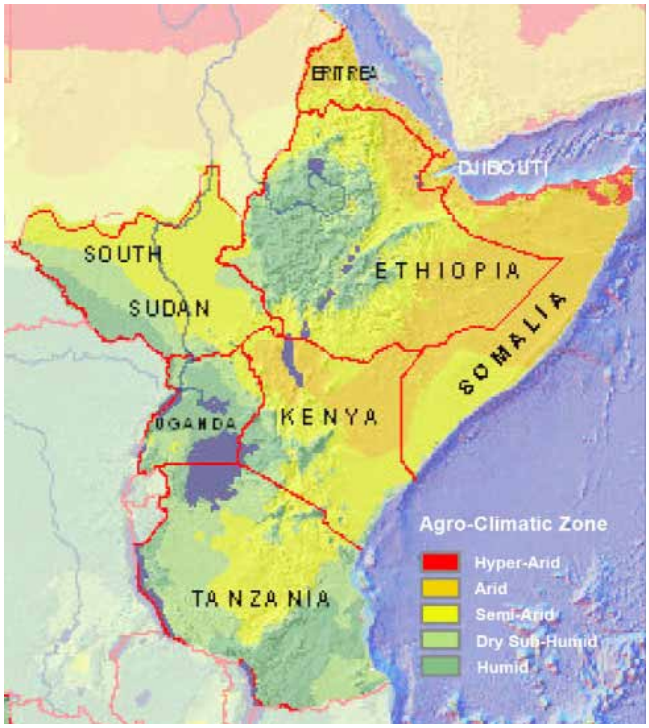

Figure 3.1 Drylands in Eastern Africa.

A classification of drylands based on level of aridity does not fully account for the variation in agro-ecological conditions in the drylands of the Eastern African region for two reasons. First, the regions' significant topographic variation creates drylands from sea level to 2500m and above which causes significant thermo-climatic variation within arid, semi-arid and sub-humid systems. Second, the equatorial drylands of Eastern Africa have a bimodal rainfall pattern, with long rains from March to May and short rains from October to December. The exact distribution of areas with uni-modal and bimodal rainfall in the Eastern African region is not well known, due to the general scarcity of rainfall stations in the drylands. Analysis of the length of green vegetation from long term satellite imagery allowed [1] to assess the length of the growing season and localize areas with one and two growing seasons (Figure 3.2). The analysis demonstrated that the bimodal pattern of vegetation greenness extends to the north to northern Ethiopia and Somalia. South of the equator the two seasons merge into a single green season near the Kenya-Tanzania border.

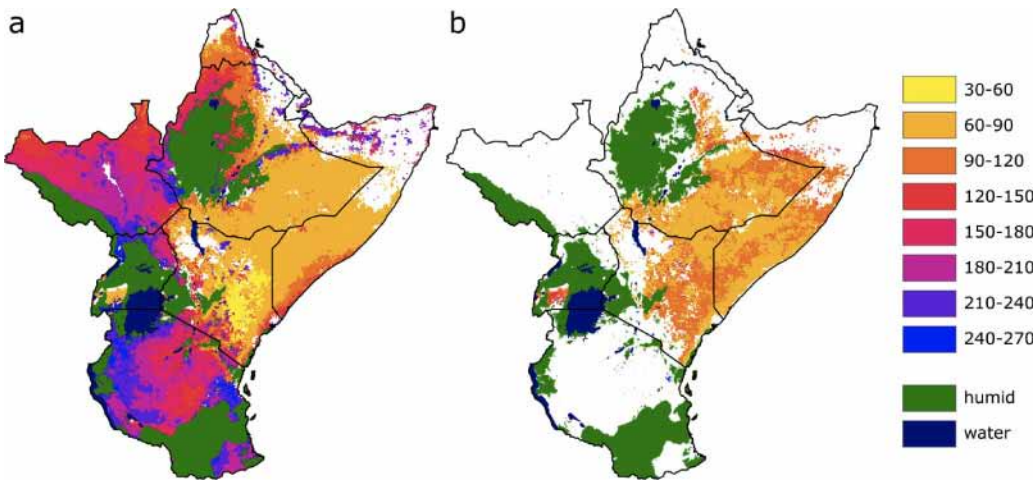

Figure 3.2 Length of the growing season (days) for Eastern Africa based on 30 years of NOAA AVHRR data for the first (a) and second (b) season.

The above approaches classify African drylands according to long term average agro-ecological conditions. Weather conditions vary from year to year leading to variation in length of the growing season between years. Vrieling et al., [1] also estimated the variability of seasonal duration as expressed by its coefficient of variation (c.v.). Figure 3.3 reveals that the drylands of Eastern Africa have a very high inter-annual variability in length of growing season, particularly for the areas with bimodal distributions. Another region with a very high c.v. for length of the season is the Kenyan Tanzanian cross-border part of Maasai land. Noteworthy is that the remote sensing imagery reveals that the drylands in Eastern Africa has patches with inter-annual variability in seasonal length greater than 0.20 (Figure 3.3), which is higher than the variability in the Sahel with a unimodal rainfall distribution[1].

The arid lands have sparse vegetation used almost exclusively for pastoral grazing. The semi-arid and the dry sub-humid lands are characterized by either one or two rainy seasons with mean annual precipitation (MAP) ranging from 500–750mm per year. Agro-pastoral and mixed farming systems based on drought-tolerant short to medium duration cereals, sorghum and finger or pearl millet and pulses are common and maize is grown for its potential and popularity as a food but often fails during drier years. Other food crops include cassava, and sweet potatoes while tobacco, cotton and sunflower are important cash crops. *Mangifera indica* (Mango) is produced where enough rainfall is received or where irrigation is available, while tree species such as *Vitex payos* and *Balanites aegyptiaca* are harvested for their edible leaves and fruits.

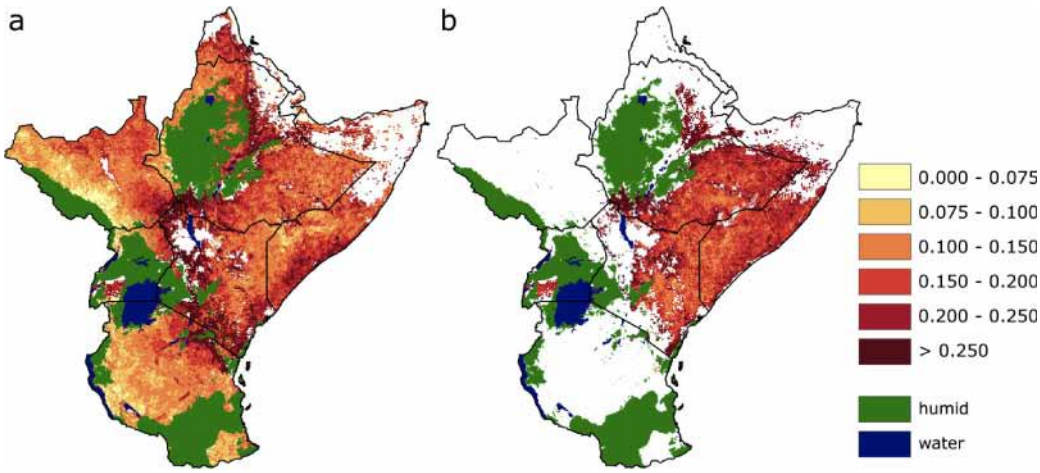

Figure 3.3 Coefficient of variation (c.v.) of length of the growing season for Eastern Africa based on 30 years of NOAA AVHRR data for the first (a) and second (b) season. Source: [1]

Source: [1]

3.2 The water cycle

Water is the most critical limiting resource for plant growth in drylands. In Eastern Africa, mean annual precipitation (MAP) decreases when moving inland from the coast and increases with elevation. People use two fractions of the rainfall: the first is the blue water, which is stored in water bodies (streams, rivers, ponds and lakes) and groundwater; the second is the green water which is transpired by plants through their stomata to allow the gas exchange that permits photosynthesis and the production of sugars, the energy carriers supporting life on earth. In drylands much of the rainwater is evaporated directly from the substrate without being converted to green or blue water. The Green Water Use Efficiency (GWUE) is the percentage of rainwater used for transpiration and primary production. The GWUE in African crop- and rangelands of 2% and 16% (De Leeuw, unpublished) is lower than the GWUE of up to 50% achieved under similar conditions in the USA with better soil evaporation control.

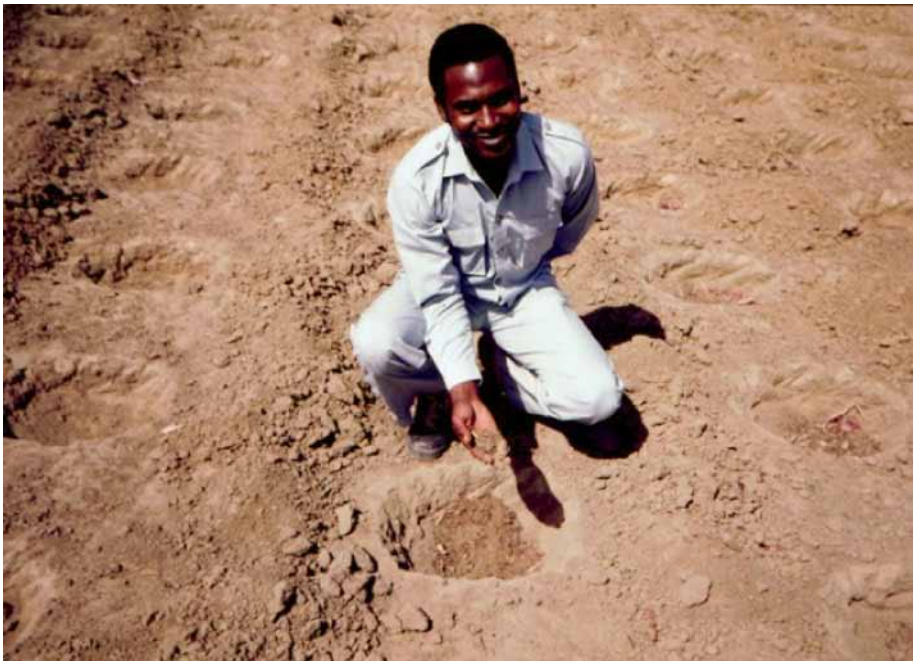

Figure 3.4 Planting pits in Burkina Faso, Photo Critchley.

These low GWUEs imply that there are ways to increase the green water use efficiency and primary production through interventions that increase the proportion of green water while promoting the infiltration and decrease evaporation and runoff. These include techniques that promote the in-situ infiltration of a greater proportion of the rainwater into the soil, for example through zai pits (Figure 3.4), terraces, ditches and minimum tillage techniques. In pastoral and agro-pastoral areas, retaining good vegetative ground cover, including grass, reduces evaporation and increases infiltration. A second range of water harvesting techniques, which store water for later use for domestic and agricultural purposes include ponds, check dams and weirs, and sand/sub-surface dams. Agricultural water harvesting techniques are most effective when combined with improvements in soil fertility. When water stress is reduced, the response of growing crops depends upon nutrient levels in the soil. Conservation agriculture is a strategy that combines a variety of techniques including minimum tillage, crop rotation, mulching and micro-dosing so as to increase soil moisture and nutrient availability. In recent years, ICRAF has improved conservation agriculture by incorporating tree species into farming systems. The species include *Faidherbia albida*, *Calliandra calothyrsus, Combretum glutinosum* and *Gryricidia sepium*.

Figure 3.5 Evergreen agriculture with *Faidherbia albida* in Zambia, Photo Mei Xie.

This new concept dubbed "Evergreen Agriculture" increases and stabilizes production as well as improves resilience of the entire farming system [2, 3]. In the example in Figure 3.5, the conservation agriculture plot was tilled with a hand hoe and planted with *Faidherbia albida* at a spacing of 10m x 10m. The average maize yield was 5,000 kg/ha and carbon increased by 4% of over seven years.

3.3 People in Eastern Africa drylands

The total population of the Eastern African region (estimate for 2013) stands at 250.3 million people (Table 3.1). Ethiopia has the largest population with 94 million people while Djibouti is the least populated country. Nation-wide population densities vary from 16.3 people per km^2 in South Sudan to 176.4 in Uganda.

Table 3.1 Population, population densities and fraction of crop and non-cropland for the countries of Eastern Africa

Country	Population million	Population density N/ km^2	Cropland %	Non cropland %
Djibouti	0.79	34.3	0.09	99.91
Ethiopia	93.88	93.9	14.20	85.80
Eritrea	6.23	61.7	5.88	94.12
Somalia	10.25	16.3	1.77	98.23
Kenya	44.04	77.4	10.60	89.40
S. Sudan	11.09	17.2	--	--
Uganda	34.76	176.4	37.05	62.95
Tanzania	49.26	55.6	14.04	85.96
Total	250.30			

There is a highly significant positive relation between human population density and the fraction of the lands in use as croplands (Figure 3.6). Remarkable also is that the vast majority of land is not used as croplands, a phenomenon that holds for all countries. A large proportion of this land is located in the drylands and consists of rangelands used for extensive livestock keeping.

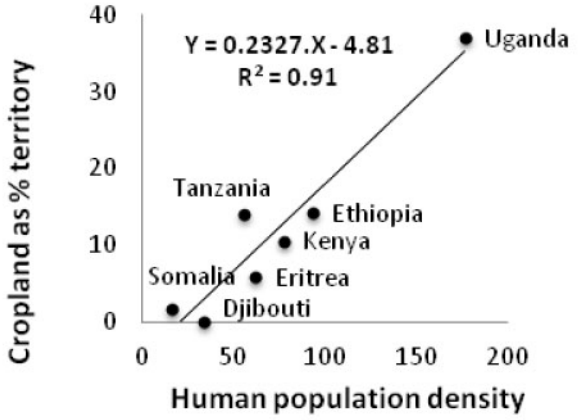

Figure 3.6. Relation between human population density and fraction of the national territory used as cropland for seven Eastern Africa countries (South Sudan excluded for lack of land use data).

At sub-national level population densities change from high potential highlands and near metropolitan areas with over 800 people per km^2 to less than 30 people per km^2 over most of the region in lowland and dryland areas (Figure 3.7).

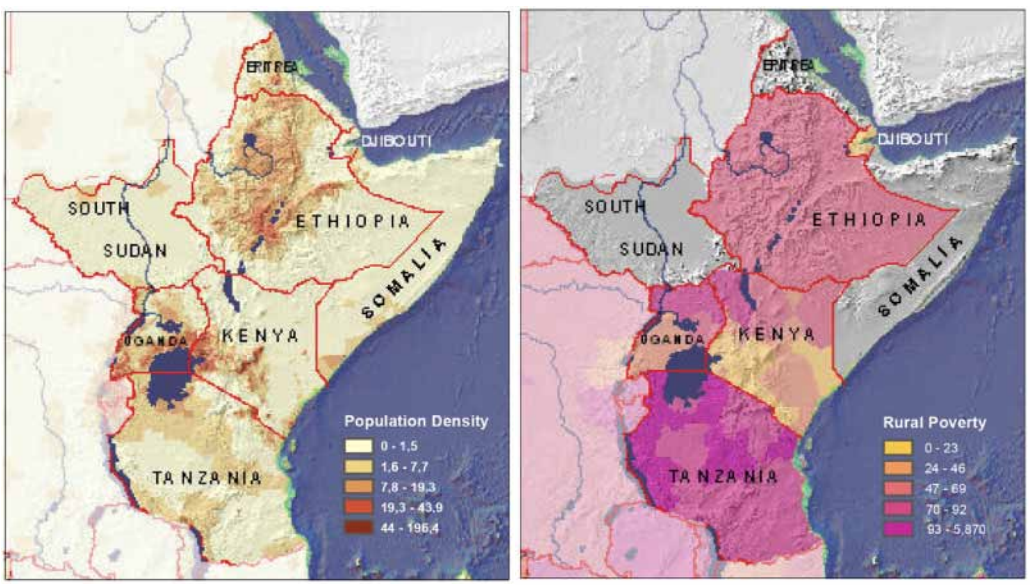

Figure 3.7 Left: Human population densities, **Right:** Percentage of the population living below the poverty line of 1.25 US$/day. Source: Harvest Choice.

3.4 Poverty and inequality

Poverty is widespread in the drylands of Eastern Africa. Poverty has been mapped at sub-national level (Figure 3.7) for several but not all countries in the region. The map shows higher than national average levels of poverty in the drylands of northern Kenya and northern Uganda. Tanzania as a country has a poverty level of 80%, similar to Turkana district in northwest Kenya.

Poverty assessments are often based on measurable sources of income. However, income as a sole measure of poverty has been criticized as inadequate since it fails to evaluate other benefits from nature that are not accounted for including assets such as trees on farm and livestock that are important but frequently undervalued components of the wealth of people in drylands [4]. Income poverty may be transitory or chronic. Transitory poverty is when shocks affect households but leave them with the ability to recover either on their own or aided through traditional or formal safety nets, including informal and formal insurance, communal pooling and disaster assistance. Chronic poverty, on the other hand, is when households are locked into poverty in the long-term, and are unable to escape without external assistance.

High levels of poverty are not necessarily related to a lack of opportunity to secure livelihoods in the drylands, but rather to the isolation of dryland communities from means of investment and earning. Often, while the better-watered parts of countries have developed, the drylands have been left with historical levels of poverty and destitution. It has always been a challenge for the communities living in the drylands to adapt to the severe ecological challenges that they encounter, but with proper economic links to areas where there is a demand for the products of the drylands, there should be better potential to improve economic conditions in the drylands.

The fact that huge dryland areas are left as sinks of poverty cast doubt on the adequacy of the policies of donors and national governments, and whether development and relief efforts have been enough to genuinely transform poor economies or serve to perpetuate poverty traps. There has been significant investment in relief in the dry areas of Eastern Africa. A total of 13.3 million people needed assistance in Ethiopia, Kenya, Somalia and Djibouti during 2011 as a result of what aid agencies said was the worst drought in the region in six decades. This was the culmination of a decade during which relief spending had increased greatly. During this time, spending on Disaster Prevention and Preparedness (which includes the effects of drought) was very low (Table 3.2).

Table 3.2 Average Annual Donor Spending on Disaster Prevention and Preparedness (AADS-DPP) before the 2011 Horn of Africa drought. Source [5] [6]

AADS-DPP	Kenya	Ethiopia	Somalia
In million US$	2.22	3.3	0.7
As % of humanitarian aid	0.91	0.59	0.19
Per person 2011 drought (US$)	0.59	0.69	0.19
As % of ODA	1.4	0.9	0.3

Recently, priorities have begun to change, with an increased emphasis on development investment in the expectation of reducing disasters. The international community announced a new partnership to strengthen resilience against disasters in the Horn of Africa [7]. Centres of the Consultative Group on International Agricultural Research (CGIAR), under the coordination of the International Livestock Research Institute (ILRI), have joined with Food and Agriculture Organization of the United Nations (FAO) to support the partnership. These welcome developments highlight a determination to fight poverty in drylands through measures that increase resilience, and put proper emphasis on development investment to bring about transformation and a shift from dependence on relief spending. On the same note, a summit was held in Nairobi on 9th September 2011 to explore how to build drought resilience and sustainable livelihoods in the Horn of Africa.

However, there is also considerable inequity in the distribution of wealth and assets like land and livestock across and within communities. Land tenure systems differ between regions and countries, with state-owned land with user rights managed at village level in Ethiopia and Tanzania and a mixture of government trust land and communal or individually-owned lands in Kenya. In areas where land has been privatized, land ownership is typically unequal with significant impacts on income and other benefits from agriculture and other ecosystem services. In communally-owned lands, which are common in pastoral areas, it is the distribution of livestock that matters. The distribution of livestock across households is typically skewed with Gini coefficients of around 0.50 or higher [5], corresponding to a situation where 20% of the livestock owners holding 60% to 80% of all livestock. These inequity statistics exclude pastoral households who have lost and have been left without livestock and their number amounts to 50% of the population of Turkana district in Kenya. The wealthier livestock owners are thus at an advantage over the poor or livestock-less in reaping the benefits from the grazing land common pool resource.

Livestock has traditionally been the asset-buffering livelihood in much of the drylands. Pastoralists are highly skilled in maintaining optimum herd sizes while moving around the landscape to take advantage of grazing and water during different seasons. This requires not only unfettered access to traditional rangeland, but also adequate links with markets where surplus stock can be sold and food purchased. Pastoralists are dependent upon selling their animals to buy the cereals, oil, tea, sugar and other commodities that they carry with them. Unfortunately insecurity, cattle rustling, poor infrastructure and poorly functioning markets disconnect pastoralists from the economic opportunities that markets provide Droughts severely exacerbate the situation. Severe droughts kill animals leading to a loss of livestock, which is the pastoralists' main asset. When assets are lost people are prone to fall into poverty traps. Poor households that lose their herds during drought increasingly fail to rebuild their herds, facing a 'poverty trap' with too few animals to sustain a decent living [7] as illustrated in the case of Mohammed in Ethiopia presented in Box 3.1.

Box 3.1 Drought pushes Mohammed into chronic poverty in Ethiopia Source: [8]

Mohammed, 55 and illiterate, who resides in the Bati district of South Wollo Zone (Ethiopia) and heads a household of nine has been chronically food insecure for more than 10 years when he lost his only ox due to drought. He sold the animal to buy food at the time and has not been able to acquire another. Currently, Mohammed holds one hectare of farmland without grazing land. Since he owns no ox, he has been leasing out the land for share-cropping on a 50/50 sharing arrangement, an arrangement that leaves the family with too little food and income to survive. Mohammed and his family members are thus engaged in various types of daily labour activities for cash and food, and the household is a regular recipient of food aid. Mohammed asserts, ''oxen is the crucial productive asset that would liberate me from this insecurity".

Similarly poor people in crop-based systems may be forced to sell their assets including valuable possessions and even their land to overcome adverse periods, which spiral them into poverty. On the other hand, households that manage to accumulate assets or who adopt new technologies or favourable shifts in their terms of trade will grow their way out of poverty. Among the very poor populations this growth could take some time, but movement nonetheless can proceed steadily under certain enabling conditions [9].

3.5 Livelihoods, natural hazards, vulnerability and resilience

Poverty indicators focusing on income do not capture human well-being fully. This is because there are more factors that determine the ability of people to make a living. The livelihood approach [10] groups these factors under five assets that make up a livelihood. These include first the human capital representing the skills, knowledge, good health and the ability to work that together enable people to pursue different livelihood strategies and achieve their livelihood objectives. Second the social capital such as networks and relationships based on trust, reciprocity and exchanges. Third, the natural capital such as natural resource stocks from which resource flows and services useful for livelihoods are derived. Fourth is the physical capital comprising the basic infrastructure and producer goods needed to support people's livelihood. Fifth is the financial capital denoting the financial resources that people use to achieve their livelihoods such as available stocks, which can be held in several forms such as cash, bank deposits, liquid assets such as livestock, or resources obtained through credit-providing institutions and regular inflows of money, including earned income, pensions, other transfers from the state, and remittances.

The livelihood approach has found wide acclaim and application because it brings together these various components that determine human well-being. It has been used for example in analysing the asset base that underlies the well-being of people and to explore the impacts of interventions on this asset base. The livelihood approach can also be used to assess the impacts of natural hazards on human well-being. Figure 3.8 portrays the livelihood as a buffer between the risks imposed by natural hazards and human well-being.

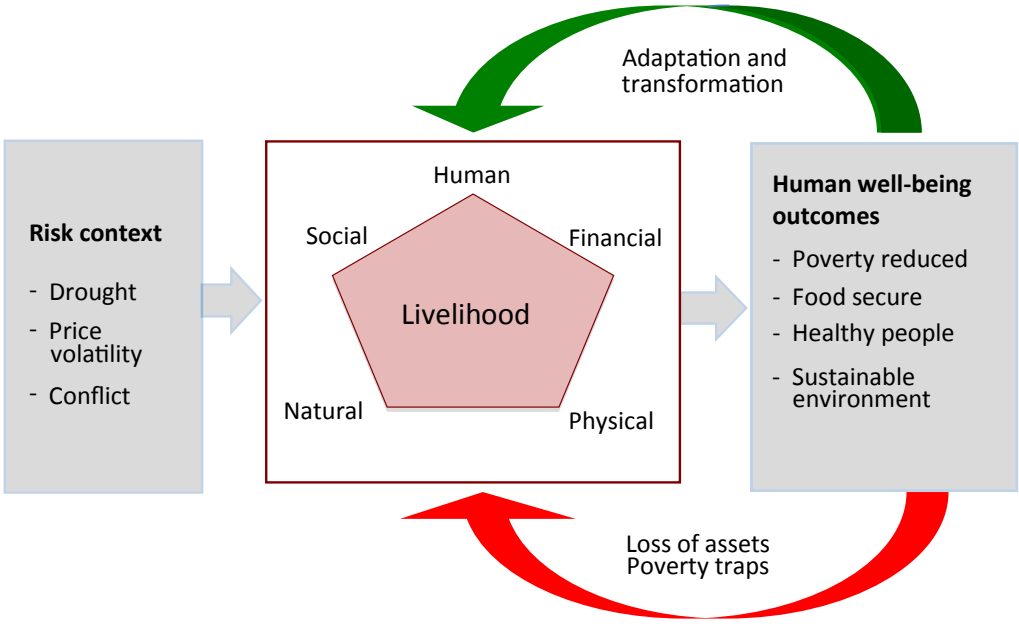

Figure 3.8 Livelihoods buffering households against natural hazards in drylands with a negative feedback loop of asset loss and a positive feedback loop of adaptation and transformative change weakening respectively strengthening livelihoods.

A livelihood is classified as sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in future, while not undermining the natural resource base [10]. The livelihoods in the drylands of Eastern Africa are affected by a number of natural hazards. Repetitive drought is the most prominent natural hazard; others include floods and animal and human diseases triggered by these. Other factors such as conflict, weak institutions and inadequate policies are not natural hazards, but factors that worsen the impacts of these natural hazards. People living in drylands are thus facing the risks of losing their assets from the numerous natural hazards whose impacts are worsened by other underlying issues as mentioned earlier. As such it is important to understand the concepts of vulnerability and resilience and how they relate to the way livelihoods and human well-being outcomes are affected by impacts of natural hazards.

Vulnerability is an undesirable condition referring to the characteristics and circumstances of a community, system or asset that makes it susceptible to the damaging effect of the hazard. Vulnerability is often the result of extreme poverty, especially where poor people have limited options on how to sustain their livelihoods, and exposure to hazards compromises their primary livelihood. A typical example from the drylands would be where long-term drought has begun to push food prices up and is affecting the condition of pastoralists' livestock or causing death of the animals. If the pastoralists find themselves in a position where it is difficult to sell excess stock to buy food and guard against future hunger, they will find themselves in a deteriorating situation. Similarly, vulnerability increases when there is reduction in transfer of resources such as through remittances and gifts as a result of diminished assets.

Resilience is a desirable condition, often simply considered as the converse of vulnerability, where people have the means to protect themselves from, or survive hazards. Complete protection from drought, flood and other eco-physical factors is impossible (it either rains or it does not). Communities in drylands have become very good at surviving hazards, and their resilience often allows them to survive shocks, well prepared to continue with their ways of life. Development efforts to increase resilience should aim for solutions that lead to continued progress, rather than basic coping mechanisms that help people but leave them in poverty traps [11].

The concept of resilience has various connotations, which revolve around how a system responds to disturbance. *Instant responses* include the capacity of a system to absorb a shock and to recover and regain pre-disturbance conditions. Immediate responses suffice in case of smaller disturbances which people are familiar with and for which they have developed mechanisms to cope. However, instant responses may not suffice in case of increased vulnerability or larger and unprecedented hazards. Yet, people and societies have the ability to learn from past experience, and decide to adapt or even to transform the system to respond more effectively to future disturbance. Adaptation and transformative resilience are *delayed responses* because they require time for social change. Bene et al. [12] thus propose three system-level responses included in the resilience concept: the ability to respond immediately, which they call *resistance,* in a period of small disturbance, and change of the system to acquire greater resistance; *adaptation* in times of greater disturbance; and *transformability* when disturbances become untenable.

Building resilience depends upon maximizing the value of the five "capitals" identified under the livelihoods approach: human, financial, natural, physical and social. In this way, people develop options that allow them to diversify their livelihoods, thus making them less vulnerable to certain shocks. Building resilience is an exercise that requires a holistic approach, recognizing the economic, environmental and social elements of people's development. Trees can contribute in many ways to this endeavour. Trees as natural capital for example, regulate water and soil erosion, provide browse material, pods and bark for livestock and fruits and leaves for human consumption during drought. Trees also contribute to physical capital, particularly as building materials, but also in other roles in the landscape such as windbreaks (often vital for controlling soil erosion) and in water harvesting structures. Trees have an important role to play in building social capital. Boundary trees define landholdings, and systems of tree tenure determine who benefits from trees. An increase in trees, along with the development of markets and value chains will link dryland communities to profitable urban centres where tree products are needed. For example, income from forests and trees on farms can make a significant contribution to rural households and their food security.

The collection, processing and sale of forest products (or activities involving non-consumptive use of forests such as ecotourism) are often among the few income-generating opportunities available in these areas. Women play an important role in the processing of tree and forest products. The creation of small or medium-sized forest-based enterprises can help secure better market access and share, or add value to harvested

products. Many small-scale enterprises are based on non-wood forest products (NWFPs) such as gums and resins and are good sources of income during drought. They are particularly important in arid and semi-arid areas where agricultural production is more vulnerable to external threats such as drought or extreme weather events. Charcoal production as a coping mechanism increases during drought when no other sources of income or food are available as illustrated in the case of Veronicah in northern Kenya presented in Box 3.2 and has potential to be made sustainable as discussed in a later section on wood fuel. Equally important and widespread is the collection of firewood for income.

Box 3.2 Charcoal burning as a coping mechanism to generate income during drought

> "We either burn charcoal or die of starvation. Manual work is no longer available, as those who used to employ us to do house chores are also affected. We [charcoal sellers] are considered a nuisance, enemies to the environment, and our charcoal is often confiscated. But we deserve to be assisted rather than condemned." The Guardian 20 July 2011.

Human capital is needed to capitalize on the value of trees. At present, people destroy trees for immediate benefits even when they are aware of future impacts, possibly due to lack of other options for income generation. Farmer-managed natural regeneration (FMNR) in parts of Africa clearly demonstrates the benefits of nurturing trees. With the proper development of relevant human capital, people will be able to exploit trees to a much greater extent, and develop new and diversified livelihoods that are much more resilient to the hazards of the drylands.

However, trees may not be considered by communities as direct building blocks of resilience where for example, forest (7 scores) or natural resource management (83 scores) are rated quite low compared to peace and security (792 scores) and water (598 scores) as found through Community Based Resilience Analysis (CoBRA) by United Nations Development Programme (UNDP)'s Drylands Development Centre in Kenya and Uganda (UNDP, forthcoming). CoBRA help the drought/disaster affected communities better engage in the process of defining and identifying "good disaster risk reduction (DRR) practices" in a meaningful and systematic fashion, in recognition of the current absence of shared understanding of "good", "best" and "success" and indicators/comparable data to measure tangible long-term impacts of the DRR interventions. The CoBRA assessment also assists the communities in internalizing the term "resilience" in their specific contexts.

This chapter introduced the drylands of Eastern Africa and developed a narrative on the importance of strengthening resilience of the livelihoods of people living in this region. Trees may contribute to enhancing this resilience, but their possible role is not clear. Shedding clarity on the role of trees requires insight into the multiple benefits that trees provide. The next chapter argues that an ecosystem service perspective is an appropriate approach to assess the multiple resilience enhancing benefits from trees.