

Ahmed E. Sidahmed

2.1 Introduction

2.1.1 Definition of Drylands and the Geographical Context and Distribution

There is no unique definition of the term drylands. While FAO and UNCCD define dryness based on the *length of the growing period LGP* (Box 2.1), the UN Environmental Programme (UNEP) uses the *aridity index* – AI – of 0.65¹ as the threshold below which both tropical and temperate areas are considered drylands (Millennium Ecosystem Assessment 2005). The use of aridity index has been endorsed by the 195 parties to the United Nations Convention to Combat Desertification (UNCCD) (World Bank 2015). Water scarcity in the drylands is caused by a faster rate of surface evaporation and evaporation from plants (Middleton and Thomas 1997).

In contrast the vast areas of the dryland ecosystems are underutilized, and most of the areas suitable for cropping or grazing are degraded by overuse or misuse. Rodríguez-Iturbe and Porporato (2004) described the drylands as complex, evolving structures whose characteristics and dynamic properties depend on many inter-related links between climate, soil and vegetation. The drylands are commonly classified into four subtypes: hyperarid lands, arid lands, semiarid lands and dry subhumid lands (Table 2.1). However, UNCCD considers the hyperarid lands as deserts and excludes them from dryland definition but for the purposes of this book,

¹ The *aridity index* measures the ratio of mean annual precipitation to mean annual potential evapotranspiration: a ratio of 0.65 means that potential evapotranspiration is 1.5 times greater than mean annual precipitation.

A.E. Sidahmed (✉)
Senior Adviser (Consultant) FAO Investment Centre, Africa Region TCIA,
Room D517 FAO, Rome, Italy
e-mail: ahmedsidahmed.contacts@gmail.com

Box 2.1 The Widely Accepted Definitions of the Drylands

Two of the most widely accepted definitions are those of FAO and the United Nations Convention to Combat Desertification (UNCCD):

- FAO defined drylands in 2000 as those areas with a length of growing period (LGP) of 1–179 days. This includes regions classified climatically as arid (1–74), semiarid (75–119) and dry subhumid.
- Under the UNCCD classification in 2000, drylands are characterized by a P/PET of between 0.05 and 0.65. The UNCCD classification employs a ratio of annual precipitation to potential evapotranspiration (P/PET). This value indicates the maximum quantity of water capable of being lost, as water vapour, in a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water. Thus, it includes evaporation from the soil and transpiration from the vegetation from a specific region in a given time interval.

Source: FAO (2008). Waters and Cereals in Drylands <http://www.fao.org/docrep/012/i0372e/i0372e01.pdf>

Table 2.1 Regional extent of the drylands

Region	Aridity zone							
	Arid		Semiarid		Dry-humid		All arid lands	
	1000 km ²	%	km ²	%	km ²	%	km ²	%
Asia (incl. 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
N. America	379	2	3436	16	2081	10	5896	28
S. America	401	2	2980	17	2223	13	5614	32
C. 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

Source: FAO (2008). Waters and Cereals in Drylands – <http://www.fao.org/docrep/012/i0372e/i0372e01.pdf>

we may deal with true deserts as part of the global land that is used to support people, their livestock and wild plants and animals that are part of global biodiversity.

For the purpose of management, the international research and development community resolved to categories the drylands into two: (i) marginal areas with high vulnerability in which a modest increase in productivity (10–20%) is targeted; (ii) areas with higher production potential with scope for sustainable intensification with targets to increase productivity by 20–30% (CGIAR 2012). According to the United Nations Convention to Combat Desertification (UNCCD) classification

system, the drylands cover 40% of the earth's land surface. However, the areas classified as drylands vary between regions and continents. As illustrated in Table 2.1, 43% of Africa, 39% of Asia, 32% of South America, 28% of North America and 24% of Europe are dryland areas. According to Millennium Ecosystem Assessment (2005), there is a significantly greater proportion of drylands in developing countries (72%), and the proportion increases with aridity. Almost 100% of all hyperarid lands are in the developing world.

Drylands are home to some of the most unique biological diversity on the planet. Drylands are home to 17% of the global Centres of Plant Diversity, 47% of Endemic Bird Areas, 23% of Global Terrestrial Ecoregions and 26% of protected areas worldwide (White 2002). Dryland species' diversity is influenced by dryland ecology and extent of aridity and is highly resilient or tolerant to drought and salinity. For example, the dryland ecosystems of sub-Saharan Africa cover a variety of terrestrial biomes including grasslands at various altitudes and latitudes, tropical and subtropical savannahs, a variety of dry forest and woodland ecosystems and coastal areas, which are extremely heterogeneous.

The drylands are the home for about one third (about 2.5 billion people) of the global population, support 50% of the world's livestock and grow 44% of the world's food (CGIAR 2012). The contribution and future potential of the drylands to the overall global economy is significant, especially when considering nonagricultural wealth (oil, mineral, sources of renewable energy such as solar and wind). According to the Millennium Ecosystem Assessment (2005), the dryland populations on average lag far behind the rest of the world on human well-being and development indicators, and most majority of them (90%) live in the developing countries (UN 2011). Drylands have three primary economic functions: as rangelands (65% of the global drylands including deserts), as rain-fed farmland and irrigated farmland (25%), and as forest or sites for towns and cities (10%), which are growing rapidly. They include the world's driest places (hyperarid deserts such as the Atacama in Chile and the Namib in southwest Africa) as well as the polar regions.

Most of the 30% of the dryland inhabitants who depend on agriculture for their food security and livelihoods are vulnerable and marginalized small farmers and herders, and they are the most influenced by climate change. Most of the world's poor live in drylands including 400 million "poorest of poor" who survive on less than US\$1 per day (CGIAR 2012). Furthermore, the drylands lose 23 ha/min to drought and desertification – a loss of 20 million tons of potential grain production every year.

The rural people living in the drylands are typically grouped into nomadic, semi-nomadic, transhumant and sedentary smallholder agricultural populations FAO (2008). The dryland farming systems are very diverse, vary according to the agroecological conditions of each region and are mostly coping with uncertainties of rain and lack of soil moisture. The major farming systems of the dryland areas vary according to the agroecological conditions of each region. For example, a study conducted by the Land Degradation Assessment in the Dryland project (LADA 2008) identified the major farming systems in the drylands according to the socioeconomic information, agroecology and possibilities for irrigation.

Cereal cultivation (indigenous or improved varieties) dominates dryland farming. Livestock production is a major activity of the dryland agricultural systems and is raised by most of the rural and peri-urban households, although there are noticeable degrees of wealth among some nomadic individuals; most of the poor pastoral communities mix herding with some subsistence farming during favourable years. Also, there is considerable livelihood diversification among the dryland people (e.g. petty trade by women and charcoal collection by men) within the households (Headey and Taffese 2012). Nowadays, year long migratory pastoralism seldom exists as nomadism gave way to seasonal migration (e.g. transhumance pastoralism). Whereas part of the household and herd is migratory, the remainder (typically the elders, women and school children) tends the breeding female and the less vigorous animals. Also, there are sedentary smallholder farming households that practice rain-fed (shifting) or irrigated crop farming often combined with livestock production. This is mainly because livestock is an important user of the natural resources (land, water, nutrients and biodiversity), an important food and wealth commodity and an important convertor of large amounts of low value byproducts and waste into valuable products (The Global Agenda for Sustainable Livestock). However, the productivity is challenged by high climatic variability, various forms of land degradation, loss of biodiversity (CGIAR 2012), limited access to technology poor market linkages, weak institutions, lack of partnerships and marginalization and exclusion of rural people.

2.2 Recent Trends

2.2.1 Impact of Climate Variability on Drought Intensity

There are three major types of climates in the drylands – tropical, Mediterranean and continental. Typically the dryland seasons are hot and dry, moderate and rainy and cool and dry (FAO 2008). Frequent diurnal fluctuations restrict plant growth within the three seasons. This is further complicated by diverse structure and physiochemical properties of the soils. Large rivers originating from the highlands (e.g. *the Nile, Tigris-Euphrates, Indus, Ganges, Senegal, Niger and Colorado Rivers*) are the major sources of water in the drylands. Groundwater and rainwater are important sources. Whereas the rainwater is erratic (especially in the arid zones) and mostly lost by evapotranspiration or runoff, the recharge of the groundwater is dependent largely on the amount, intensity and duration of the rainfall and soil properties.

The past 250 years witnessed unprecedented increase in human and livestock population and massive internal and international displacements caused by industrialization, urbanization, conflicts and wars (FAO 2008). These trends were accompanied by fossil fuel combustion and land use change (including inter alia deforestation, biomass burning, uncontrolled harvesting of wildlife, draining of wetlands and concentration of very limited varieties of food crops and livestock species, ploughing and use of fertilizers). As a consequence the genetic diversity and ecological balance were severely disrupted and reduced. A major drastic consequence was the global increase in atmospheric concentrations of carbon dioxide (CO₂) and other

greenhouse gases particularly methane (IPCC 2007). These changes are associated with extreme temperatures that alter the hydrological cycles and might result in extreme events such as droughts and floods (Woznicki et al. 2015). More recent studies confirmed that climate change is one of the major threats to the genetic diversity of animal resources (FAO 2015d).

Most of the international community and governments have acknowledged the substantial scientific evidence (Stern 2006, 2007) that the recent and future rapid changes in the earth's climate are human induced, caused by accumulations of CO₂ and other greenhouse gases (GHGs). Widely accepted predictions show that the ongoing pattern of climate change will not only raise temperatures across the globe but will also intensify the water cycle, reinforcing existing patterns of water scarcity and abundance, increasing the risk of droughts and floods.

Also, widely accepted are the IPCC (2007) assessment that hot extremes, heat waves and heavy precipitation events will continue to become more frequent. According to IPCC, frequent and protracted droughts in most subtropical land regions are likely caused by decreases in precipitation (see Box 2.2 for definition of Droughts). Examples of “*meteorological drought*” are reported in the results of research conducted in the semiarid agricultural basin of Khuzestan region of Iran, where drought occurrence is more frequent in the warmer and drier climates of the basin (Hosseinzadeh et al. 2015). On the other hand, examples of “*socio-economic drought*” are reported in Thessaly Region of Greece where annual drought severity

Box 2.2 Drought

The terms drought and aridity are sometimes used interchangeably, but they are different. Aridity refers to the average conditions of limited rainfall and water supplies, not to the departures from the norm, which define a drought. A drought is defined as a departure from the average or normal conditions, sufficiently prolonged (1–2 years) as to affect the hydrological balance and adversely affect ecosystem functioning and the resident populations. The National Weather Service, 2004, recommended four different ways for the definition of drought:

- *Meteorological drought* is a measure of the departure of precipitation from normal. Due to climatic differences, a drought in one location may not be a drought in another location.
- *Agricultural drought* refers to situations where the amount of soil water is no longer sufficient to meet the needs of particular crop.
- *Hydrological drought* occurs when surface and subsurface water supplies are below normal.
- *Socio-economic drought* describes the situation that occurs when physical water shortages begin to affect people.

Source: FAO (2008). Waters and Cereals in Drylands <http://www.fao.org/docrep/012/i0372e/i0372e01>.

is increased for all hydrological areas, with the socio-economic scenario being the most extreme (Loukas et al. 2008).

Agriculture is negatively affected by climate variability in the dryland areas. Inconsistent climatic patterns, erratic rain, excessive heat and overuse of the natural resources contributing to the loss of millions of hectares of the productive land each year adding to the vulnerability and poverty of the dryland farmers. A case in the point is the impact of climate change on drought intensity of the Horn of Africa and the Sahel regions. In the Horn of Africa, the livestock sector experienced five major droughts between 1998 and 2011, which killed more than 50% of the cattle in the most heavily affected areas and decimated the livelihoods of between 3 and 12 million people, depending on the year (World Bank 2015). In the Horn of Africa region, the drought of 2010/2011 was the worst in 60 years leading to a severe humanitarian and food crisis affecting over 13 million people mostly from Somalia, Kenya and Ethiopia (FSNAU 2011). The two major droughts that occurred in the 1970s and 1980s in the Sahel region led to the deaths of about one third of all cattle, sheep and goats (Lesnoff et al. 2012), where relatively mild drought between 2010 and 2012 was the cause of food insecurity of 12 million people (Oxfam 2012).

The impact of 2010 and 2011 in the Horn of Africa and the Sahel, respectively, on crop and livestock production was devastating (IGAD 2013a, b). Only 30% of the households in the Sahel and the Horn of Africa had adequate livestock assets to stay above poverty in the face of recurrent droughts. As a result of population growth, the number of households is projected to drop to 10% by 2030, while 60% of the households are likely to feel pressure to drop out of livestock-based livelihoods, with the remaining 30% of households projected to stay in the system while remaining vulnerable to drought and other shocks (World Bank 2015). Also, it was projected that by 2030, without resilience and mitigation measures, the number of farming-dependent households in the Sahel and the Horn of Africa that are poor and vulnerable to drought to increase by around 60%.

2.2.2 Impact of Recurrent Droughts on Conflict Dynamics

Some of the semiarid and dry humid zones are becoming drier and hotter (World Bank 2015). Increasing temperatures in the drylands are altering climate variability, the traditional water and land use patterns and plant growth dynamics. For example, the evapotranspiration decrease is slight likely caused by the increase in the atmospheric CO₂ concentrations (Woznicki et al. 2015). Climate change can alter the hydrological cycle, which may result in extreme events such as floods and droughts. Complications caused by the rapid increase in the human populations of the drylands inhabitants during the past century are expected to intensify by further increase in the twenty-first-century population. Moreover, higher population density in the drylands, combined with increasing interest from outside investors in large-scale commercial agriculture and/or extractive industries, will put additional pressure on a fragile natural resource base, pushing it in some cases beyond its regenerative capacity (World Bank 2015). In the absence of viable land use policies and

regulations and because of the chronic land tenure problems in many developing countries, such changes are leading to intensified conflicts between the livestock herders and the cultivators (World Bank 2015).

The most recent impact of drought-triggered conflict on the agriculture sector is very well demonstrated in the Horn of Africa and the Sahel Region of West Africa. Prolonged droughts were the major cause of the ineffectiveness of every attempt made to reduce poverty and insecurity in the dryland areas of the Horn of Africa and Sahel, even in the countries that witnessed economic growth (Fosu 2009; IOA 2012). By the time of writing the IOA report, it was estimated that drought-related acute food shortage in the Sahel region of West Africa and the Horn of Africa have left about 18.7 million and 11.7 million people, respectively, in need of emergency assistance. Violent internal and cross-border conflicts and ethnic unrest involving fighting over water and grazing resources, stealing livestock and women erupted in various countries and contributed to displacement of millions of people, disruption of transportation and market transactions and subsequently hunger and starvation. According to the report, sub-Saharan Africa was responsible for 88% of the global conflict death toll between 1990 and 2007, in addition to over 9 million refugees and internally displaced people.

The geopolitical and economic implications of drought on the poor and the poor countries are exacerbated in many countries by governments who because of lack of knowledge, corruption, lack of support for the development of viable land tenure systems and the intentional disregard to implement the internationally agreed upon commitments of land use governance and equitable/responsible investment practices.

For example, the recent expansion in large-scale high-technology farming systems in some Sub-Saharan African countries – e.g. *outsourced ventures of oil wealthy but water-poor countries in the Middle East in Sudan* – is impacting negatively on communities exposed to land grabbing among other injustices. Also there is emerging evidence that conflicts over land, water and feed resources is increasing in several dryland areas triggered by intensified competition for the meagre resources.

Conflict in the dryland areas is the cause and effect of vulnerability. The diverse ecosystems of the dryland areas and the dependence of the rural population, in some dryland categories, on inconsistent climatic cycles and precarious natural resources enhance the vulnerability of the drylands dwellers. This is further exacerbated by the fierce competition on land and water to meet the needs of increasing population. For example, in spite of protracted droughts, civil strife and famine, the human population of the Horn of Africa is increasing at the rate of 2.5–3.5%, with over 60% of the people being youth (IGAD 2013a, b). The increase in population is reflected in the dramatic increase in land and water for cropping and livestock production. This is reflected in the increase in cropping intensity (both caused by expansion in arable land and multiple cropping intensity – MCI^2) in the drylands – especially in Africa and Asia (OECD 2009). OECD recorded similar acceleration in livestock productivity caused by advances in technology, disease control, genetic improvement and stock management (OECD 2009).

² MCI multiple cropping intensity is the sum of area harvested for different crops during the year divided by the total harvested land.

Table 2.2 Classification of drylands by aridity index in aridity index global land area ESARO land

	Aridity index	Global land area ^a (%)	ESARO land area (%)
Arid	0.05 < AI < 0.20	12.1	7
Semiarid	0.20 < AI < 0.50	17.7	15
Dry subhumid	0.50 < AI < 0.65	9.9	25
Total (excluding desert)		39.7	47

Source: Adapted from IUCN- ESARO (2010)

^aDrylands without deserts account for 40% of the global land mass

Of great concern is the observation that such increases in cropping intensity and livestock production did not reduce vulnerability to droughts and poverty of the poor in the dryland areas of the developing countries. According to the World Bank (2015), the number of poor and vulnerable farming-dependent households in the Sahel and the Horn of Africa is projected to increase in the next 15 years by about 60%. This increase underscores the demographic implications that keeps the majority of farming in the drylands in the hands of the poor and subsistent small farmers who lack the resources and technology to sustain production or reduce vulnerability, and eventually leading to the eruption of conflicts and ethnic wars.

Drought-related conflicts are diverse but interrelated. There are conflicts caused by dryland communities averse to sharing traditional resources especially during drought years. There are incidents of the civil strife and quarrels that break out between communities competing on the use of livestock grazing areas or human/ livestock watering points. Livestock rustling is a tradition among communities that lack cross-border policies and national security infrastructure.

2.2.2.1 Drought-Related Conflicts

Africa is the continent mostly affected by the impact of drought on food security and social stability. According to IUCN_ERASO³ (2010), dryland climates are highly unpredictable and subject to extreme events such as droughts. The ERASO drylands occupy 47% of the land area in the 22 sub-Saharan African countries (Table 2.2) and are characterized by low economic growth, a poorly educated workforce and political weakness.

Land-Related Conflicts

Africa with its endowments of vast untapped land and water resources should be able to feed its people and to revert the food trade balance to its favour. Over 50% of the additionally available arable land is found in Africa and Latin America (OECD-FAO 2009). Only 10% of Africa's rural land is registered (AfDB 2016). This is

³ESAROEastern and Southern Africa Regional Office in this case refers to the following countries: Angola, Botswana, Comoros Islands, Djibouti, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Somalia, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

further complicated with inefficient land administration that delays transferring land title deeds and substantially increases the transaction cost (e.g. which is estimated – on average – as being twice that of the developed countries) (AfDB 2016). Furthermore, incomplete and poorly enforced land tenure laws discourage the private investors or deprive the traditional land users – especially the marginalized poor and deter any equitable options for development and poverty reduction. There are very few contested indicators, in the developing countries, that the governments pursue effective planning and management of land utilization, and wherever they do they remain voluntary and nonbinding. Weak policy and institutional frameworks are the leading cause of corruption in the agriculture sector, including land administration. Further complications result from the nature of the mostly male-dominated (in some cultures male-exclusive) titles, inheritance rights and access to land in a continent where women are the primary users of agricultural land.

The impact of failing to achieve a breakthrough in solving the chronic land tenure problems is more complicated in the dryland areas where the cyclic and unpredictable weather events create unsustainable pressure on land and water resources and increase the vulnerability of the herders and the occasional small farmers (IFPRI 2012) to drought. In the absence of such an overarching policy framework, it is not possible for governments to rationalize the conflicting land utilization needs, manage allocation of secured title and attract long-term investment in agriculture. There are African governments that treat land tenure in a top-down approach giving the president or the ruling Junta the authority to allocate land and to use it in favour of selected invasive local or foreign users. For example, the recent expansion in large-scale high-technology farming systems in some African countries – e.g. *outsourced ventures of wealthy but water-poor countries in the Middle East* – is impacting negatively on communities exposed to land grabbing among other injustices. The reversal of the Egyptian government of its support to the article in the 2014 constitution that allows the Nubians who were evicted by force as a result of building the Aswan Dam in the 1940s and the High Dam in the 1960s is just one example of poor or abusive policies that do not consider the inherent rights of the indigenous people.

Water-Related Conflicts

Water scarcity in the dryland areas is one of the major challenges to the contribution of the agriculture sector to food security (FAO 2014a, b, c, d, e, f). Pressure on water resources is aggravated by increasing and unsustainable use and heavy dependence on renewable water, which are replenished by rainfall or stored in deep aquifers. Heavy reliance on transboundary water resources is a major concern contributing to food insecurity in many dryland countries and is increasingly becoming a major trigger of regional conflicts. Moreover, the use of underground water at a speed faster than replenishment is threatening many parts of the drylands areas with desertification. Plans by some dryland countries favouring production of high water-consuming crops such as wheat and alfalfa (e.g. Saudi Arabia) are leading to water depletion (FAO 2016a).

A further pressure on water use commonly triggering conflict in several dryland area dominated countries is the shift from the traditional pastoralism to settled commercial systems (FAO 2016b). For example, In Oman and in other dryland countries, increasing human and livestock population, urbanization and infringement of roads and other infrastructure on the grazing resources have transformed livestock rearing from the community managed nomadic mobility of the pastoralists to the seminomadic-sedentary farming systems (Box 2.3). This transformation was accompanied by the increasing use of water for year-round cultivation of animal feed and for the cultivation of food and cash crops. This transformation was also accompanied by conversion of vast grazing areas into cultivated land.

Box 2.3 The Major Categories of the Livestock Producers (Meat and Dairy)

- *Nomadic (Badawi)*: The stakeholders of this very limited system are the Bedouins. The system they follow is a low-input/low-output system that prevails only in the desert and the mountainous areas. The producers rear camels, cattle, goats and some sheep.
- *Transhumance (seminomadic, traditional semimobile) – Agro-pastoral*. Very close to the Badawi in pursuit of seasonal grazing resources and supplemental feeding. Producers live in a specific area but move with livestock for feed and water and supplement seasonal grazing with sown forages, crop residues, concentrates and dried fish.
- *Sedentary mixed crop-livestock* (sheep, goats and cattle producers fattening for slaughter using mix of sown fodder, concentrates and crop byproducts). This group is the largest in the Sultanate (see Table 2.1).
- *Settled rural household* (back yard) smallholders of sheep, goats and cattle (*the most dominant production system for all livestock types*) who supplement seasonal grazing – in the neighbourhood pastures – with sown forages, crop residues, concentrates and dried fish.
- *Settled sheep, goats and cattle producers* graze commercially high-valued animals in natural rangelands during certain times of the year and provide supplemental feeding to maintain the desired requirement year-round.
- *Intensive local producers* fattening for slaughter: producers keep animals in fenced areas and manually feed animals from sown forages and purchased feed, and there is no grazing involved.
- *Intensive dairy farmers (medium and large)* with relatively fully integrated production.
- *Nomadic sheep and goats herders in the dry rangelands* supplemented depending on grazing year with imported concentrates.

Source: MAF (Oman) documents and reports (several); discussion with the Directorate General of Animal Resources senior and technical staff, limited field visit

2.2.2.2 The Climate Challenge in Agriculture and Its Impact in Food Security and Nutrition in the Dryland Areas

Climate change – typically associated with frequent weather events, heat waves, droughts and sea-level rise – is already affecting agriculture and food security globally and particularly in the dryland areas (World Bank 2015; FAO, SOFA 2016). The agriculture sector accounts for at least one fifth of the total emissions mainly from livestock and crop production as well as conversion of forests to farmlands (FAO, SOFA 2016).

The potential impact of climate change on agriculture in sub-Saharan Africa, and especially the drier climates, will be negative and would enhance poverty, malnutrition and hunger. This is because the frequency of extremely dry and wet years will increase, thus disrupting agriculture production. Also forage production will decrease remarkably, particularly in the Sahel as a result of drought and range degradation. Moreover, enteric emission of methane from ruminants in small farming systems (that make up the major livestock production) will complicate any measures to reduce global temperature. Rising temperatures will threaten wheat and maize yield in the mostly dry North Africa and near east regions.

Because agriculture is such a major contributor to global warming, the sector is expected to play a major role in any effort to reduce emission. Reduction of emission will entail unprecedented responsibilities and expenses on the governments and the farmers. The responsibility on the dryland areas will increase as adoption of application of efficient water use and cropping technologies and innovations will lead to expansion on the potentially arable lands particularly the irrigated areas.

However, reduction of emission will also contribute to sustained increase in agriculture productivity, and consequently to food security and nutrition. Adopting measures to stabilize climatic variability (e.g. Milestone Climate Change Agreements Box 2.4) would reduce the extent of food production uncertainties, avoid dramatic food shortages and – as a consequence – avert dramatic increases in food prices. According to the FAO's SOFA report, without urgent action, millions of low-income people would be directly affected in regions with already high rates of hunger and poverty. Most affected would be populations in poor areas in sub-Saharan Africa, especially those reliant on dryland agriculture (FAO, SOFA 2016).

Box 2.4 The Milestone Climate Change Agreements

The finding that the atmospheric concentration of carbon dioxide in 2005 exceeds by far the natural range (IPCC 2007) triggered a worldwide campaign to eliminate the causes of climate change and to reduce global temperature. After years of complicated negotiations, 197 nations met at the Climate Change Convention in Paris (UNFCCC, COP21 2015) and declared that they have reached an agreement to: *“hold the increase in the global average temperature to well below 2°C above pre-industrial levels.... recognizing that this*

(continued)

would significantly reduce the risks and impacts of climate change,” pursue efforts to limit the temperature increase even further to 1.5 °C and undertake and communicate ambitious efforts to contribute to the global response to climate change by strengthening the mobility of countries to deal with the impacts of climate change. All parties expressed their recognition of the importance of averting, minimizing and addressing loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage. Following subsequent dialogues on actions, the threshold for entry into force of the Paris Agreement was achieved when 94 of the 197 ratified the agreement in Paris in 5 October 2016. The international community affirmed its position to continue the dialogue and focus on actions to achieve the commitments of the Paris Agreement through sets of COPs starting with COP 22 in Morocco in November 2016. In Marrakech the heads of state, government and delegations called for the highest political commitment to combat climate change as an urgent priority, and the developed country partners affirmed a US\$100 billion mobilization goal in support of climate projects.

Sources: IPCC (2007), UNFCC – COP 21 and COP22

2.2.2.3 The Case of the Protracted Droughts in the Horn of Africa

The Horn of Africa (HOA) and the Sahel are the most environmentally vulnerable dryland areas in Africa and the world. The droughts and floods in the Horn of Africa region have been recently intensified as a result of the El Niño impact. While the El Niño triggered floods in the HoA affected more than 3.4 million people in 2006/2007, 14 million people were affected by the droughts of 2009/2010 (source: EM-DAT). Furthermore, the recent humanitarian crises caused by the 2011 drought in the Horn of Africa (IGAD 2013a, b) and the 2012 drought in Sahel attracted global attention for the magnitude of emergencies and calamities they caused (World Bank 2015). For example, over 10% (around US\$4 billion) of 2011 resources allocated by the Overseas Development Assistance (ODA) to long-term development goals in sub-Saharan Africa were redirected to costly short-term responses to humanitarian crises (World Bank 2015).

The Horn of Africa is one of the most serious hotspots of structural food insecurity, malnutrition and hunger in the world (FAO 2014a, b, c, d, e, f). The impact of the 2010/2011 drought in the Horn of Africa was the worst in 60 years (IGAD 2013a, b). The drought caused a severe humanitarian and food crisis affecting over ten million people mostly from Somalia, Kenya and Ethiopia. The crisis further complicated the social, economic, political and security situation in both Intergovernmental Authority for Development (IGAD) and the East Africa Community (EAC) regions where the combined economic impact of the drought and related shocks contributed to significant instability and losses (IGAD and FAO 2016). The 2010/2011 drought

highlighted the extent of vulnerability of the communities using these vast areas as livelihoods assets. In addition, pressures from increased human population, urbanization and infrastructure (roads, urban homes, factories) in the pastoral areas reduced the ability of the livestock keepers to cope and to mitigate the impacts of drought through their traditionally risk averse mobility strategies.

Understanding the vulnerable livelihoods of the drylands inhabitants is primary to finding sustainable solutions to the complicated drought-triggered conflicts in the Horn of Africa (IFPRI 2012). Although pastoralism is still the most dominant source of income and employment for the inhabitants of the arid and semiarid lowlands (ASAL) region of the Horn of Africa, a significant number of the inhabitants are crop-based farmers, and many others are engaged in non-farming activities in the rural and urban areas. For example, it was reported by (Devereux 2006) that almost 70% of the households in the Somali region of Ethiopia engage in livestock rearing, whereas 43% engage in cereal crop production, 17% in firewood production and 15% in charcoal production. Also according to the study smaller but significant numbers of households engage in other activities such as mat making, petty trading, cash crop production and salaried employment.

The *Karamoja Cluster* in the Horn of Africa is a typical illustration of the complexity of the dryland areas in the Horn of Africa and the events that lead to conflicts. The Karamoja Cluster comprises four cross-country political-administrative units: at the Ethiopian, Kenyan, South Sudanese and Ugandan sides – Box 2.5 (IGAD 2015). The cluster has been historically subject to recurrent droughts and disease epidemics that regularly decimated herds – Box 2.6 (Practical Action). The herders normally rebuild the herds through exchanging or loaning herds/flocks or by raiding during times of extreme environments stress. At present, and especially post the 2010/2011 protracted droughts, the conflicts intensified in the cluster areas specially as the traditional norms (for the use of water and grazing resources) were disrupted by the modern and the geopolitical realities (border, roads, expansion in cropping lands, etc). For example, more recently small groups of warriors clad with automatic arms perform criminal/profit-motivated raids. In Karamoja, currently cattle raid account for more than 70% of deaths among the males aged 30–39 years.

Box 2.5 Karamoja Cluster

At the Ethiopian Side: Bero, Surma and Dasenech Woredas

At the Kenyan Side: Turkana, West Pockot, Samburu and Trans Nzoia Counties

At the South Sudanese Side: Kapoeta, Ikwoto, Naia and Naurus in *Eastern Equatoria State*

At the Ugandan Side: Kaabong, Moroto, Amuda, Nakapiriprit, Napa, Abim and Kotido in *Karamoja Region*

Source: IGAD (2015). IDDRSI – Cluster Approach for Cross-Border Cooperation and Investments to Strengthen Drought Resilience in IGAD – Region 4th IDDRSI Platform SC meeting and GA, Addis Ababa. 25–27 March 2015

Box 2.6 The Karamoja Cluster in the Horn of Africa



The Karamoja cluster refers to an area of land that straddles the borders between southwestern Ethiopia, northwestern Kenya, southeastern Sudan and northeastern Uganda. The area is populated by 14 pastoralist tribes who share a common language, culture and way of life. The cluster is composed of semi-arid savannah grading into wooded grassland to the north and desert to the south. Rainfall is generally unpredictable and localized, making agriculture an unreliable subsistence strategy. To survive in this habitat, pastoralists have evolved management strategies that are finely tuned to the realities of their environment. Recent studies have affirmed the rationality of these strategies and have demonstrated them to be more efficient than “modern” approaches to resource utilization in these environments. Notwithstanding this, the pastoral way of life is not without risks.

Recurrent drought and disease epidemics decimate herds in the Karamoja cluster. In the past, when drought or disease decimated herds, people recouped stock and ensured their survival by exchanging or loaning stock or, in the worst cases, by raiding cattle from neighbouring tribes. Raiding was confined to times of extreme environmental stress and carried out by large groups of warriors armed with spears and arrows. Since the 1970s, however, the nature of raiding has changed. It is now a continuous activity carried out by small groups of men armed with automatic weapons and driven by criminal motivation for profit. The results are devastating. It is estimated that cattle raids currently account for more than 70% of deaths among males aged 30–39 in tribes that inhabit the region. The proliferation of modern weapons along with

(continued)

changes in traditional rules of engagement have transformed an adaptive practice into a maladaptive and ongoing conflict that has increased poverty and famine in the area, placed vast tracts of grazing land and water sources out of reach of herders and rendered many pastoralist families destitute.

While ecological disasters and livelihood dislocations from war and famine contribute significantly to endemic poverty and underdevelopment in the area, there is increasing acceptance that the root cause for the crisis lies in the political and economic marginalization of pastoralists and by the failure of governments and development agencies to devise and implement programmes aimed at sustaining pastoral production. In the past, most interventions adopted the position that pastoralism is intrinsically self-destructive and that a more progressive approach to development should steer pastoralists into other, allegedly more secure means of assuring their livelihood. After decades of failed development, planners are beginning to realize that the practices of the pastoralists make sense and that optimal use of semiarid range resources may involve continuing animal husbandry through extensive pastoralism, rather than radical shifts to new technologies of intensive commercial husbandry and dryland agriculture.

Source: Practical Action; <http://practicalaction.org/drought-resilience-in-karamoja-1>

With further dwindling resources and increased competition by the growing population on the meagre resources, conflict intensified at unpredictable dimensions and scale. For example, insufficient, corrupt or invalid land use or tenure policies strained the situation and lead to banditry, civil strife, disruption of cross-border markets and politically motivated wars at a scale that threatened the stability of the whole region. A more recent example is the sharp decline in livestock prices in Karamoja markets between December 2013 and January 2014 when civil conflict erupted once again in South Sudan (FAO 2014a, b, c, d, e, f).

2.3 Future Scope for Advancement

2.3.1 Enhancing Coping Mechanism and Resilience Through the Adoption of Measures to Minimize Drought-Triggered Conflicts

The resilience of the marginalized small agriculturists and livestock producers have substantially eroded as they failed to cope with the competing forces of population growth, advancing urbanization, commercialization and the invasive large-scale farming. Also the expansion of foreign large-scale agriculture investment from food deficit rich countries (Malaysia, Middle East Arab countries) through outsourcing is

adding a further scale to the marginalization and risks facing the smallholder agriculture in the poor dryland countries and aiding in the displacement of the indigenous Africans from their historical heritages (e.g. the progress in forced eviction by Sudan and Egyptian governments of the Nubians from south Egypt and northern Sudan).

As discussed in the previous sections of this chapter, the dryland regions are under considerable pressure caused by climate variability and climate change (see also Bawden, this volume). The negative impact on agriculture sector will increase the vulnerability and reduce the coping mechanisms of the poor agriculture and herding communities. On the bright side, the global community has understood that although most of the events leading to drought are natural and climatic, the triggers are manmade, and, therefore, mankind must invent the solutions. There are several priority actions developed at the subsectoral, sectoral, regional and global levels (CFS 2015; CGIAR 2012; IGAD 2013a, b; World Bank 2015; FAO 2016a, UNFCCC 2010). Subsequent to the Paris Agreement (UNFCCC 2015) the global leaders met in Marrakech (UNFCCC 2016) to demonstrate that agriculture is part of the solution to climate change and that *“the agriculture sector has unrivaled potential to simultaneously address poverty, hunger and climate change.”*

2.3.1.1 Emerging Strategies and Policies to Enhance Resilience in the Dryland Areas

Below are brief examples of emerging measures and strategies directly affecting the agriculture sector needed to enhance the coping mechanisms resilient to minimize conflicts of the dwellers of the drylands particularly the poor farmers and livestock producers.

Global Consensus: Enhancing Resilience of Small Agriculturalists and Livestock Producers Against Risks and Variability in the Drylands

From the bright side is the fact that the Committee on World Food Security (CFS) meets occasionally at FAO HQ to discuss and endorse policy recommendations on various aspects of sustainable agriculture. For example, the High-Level Panel of Experts (HLPE) on Food Losses and Waste (HLPE 2014) (see Sect. 3.1.1.2 below), the endorsement of the CFS' Framework for Action for Food Security and Nutrition in Protracted Crises (CFS 2015) and the report on Sustainable Agricultural Development for Food Security and Nutrition: What roles for livestock (HPLF 2016; ILRI 2016)? Below is a summary of selected recommendations aiming to enhance resilience of the dryland small agriculturalists and livestock producers against risks and variability for which there is evident global consensus:

- (i) Coordinating actions, including through existing mechanisms, that support national policies and actions promoting food security and nutrition
- (ii) Strengthening the security of tenure rights in line with the CFS Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security, including in all cases of conflict

- (iii) Developing policies and tools and improve capacity, to assess, mitigate and manage risks, and reduce excessive price volatility and their impacts on the most vulnerable
- (iv) Investing in and strengthening prevention, preparedness, impact reduction and disaster risk reduction strategies for more timely and cost-effective responses
- (v) Supporting responsible investments which create economic opportunities for smallholders, particularly rural women and youth, as well as for members of affected and at-risk populations, vulnerable and marginalized groups and people living in vulnerable situations
- (vi) Understanding, using and supporting the existing capacities, knowledge, practice and experience of affected households and communities as entry points for policies and actions
- (vii) Encouraging policies and actions aimed at strengthening sustainable local food systems and fostering access to productive resources and to markets that are remunerative and beneficial to smallholders
- (viii) Facilitating the adaptation to and mitigation of climate change in agricultural systems in line with the Paris Agreement and with particular support for smallholders and pastoralists, and women's role in food systems
- (ix) Supporting appropriate and sustainable social protection programmes, including through predictable, reliable, rapidly scalable safety nets, to mitigate and manage food security and nutrition risks
- (x) Enhancing access to insurance for small agriculture and livestock systems, including index-based insurance
- (xi) Facilitating access to markets for the vulnerable and marginalized, including through cash transfer and voucher modalities, or other solutions adapted to local contexts, and based on a thorough analysis of local risks and needs
- (xii) Improving plans for animal disease prevention, control and surveillance, including through cross-border cooperation on transboundary diseases, in order to foster early warning and early action on disease control, spread and eradication, with emphasis on the Global Eradication

Global Consensus: Contribution of the Reduction of Food Losses and to the Reduction of Pressure on Natural Resources and the Emission Intensity

Sustainable agriculture sector practices could contribute to the reduction of soil degradation and water depletion in the dryland areas (FAO, SOFA 2016). In addition, smart agriculture practices could play a major role in the mitigation of the impact of climate change by reducing intensity of emission. This effort can be complemented by actions aimed at reducing food losses and waste and changing food consumption patterns.

Food loss and waste (FLW) along with both the production and supply chains is endemic worldwide inclusive of the dryland developing countries. Most of the dryland countries are food deficit and are net food importers. About one third of all food produced in the world is lost or wasted postharvest. Food crises intensify during drought years. Food loss is more of an issue in the developing countries mainly

Table 2.3 Distribution of FLW along the food chain in different regions of the world

Regions/	Distribution of FLW (9%)					
	Harvest	Postharvest	Processing and packing	Distribution	Consumption	Total
NENA and Central Asia	10.8	7.8	6.3	5.6	5.5	36
North America and Oceanica	10.5	3.5	3.4	2.4	12.6	32
Europe and Russia	11.3	3.4	3.9	2.8	10.6	31
Japan, Korea and China	9	6.6	3.1	4.4	10.3	33
Latin America	13.4	7.5	5	4.1	3.7	34
Sub-Saharan Africa	12.5	12.7	4.5	4.6	1.3	36
South and SE Asia	8.7	9.6	2.7	4.6	2.6	26

Source: HPLE (2014). Food Losses and Waste in the context of sustainable food systems, a report by The High-Level Panel

because of the weakness in the food supply chain (The Economist 2014) and inefficient use of the production resources. Food loss constrains food security by reducing the availability of nutritious foods. On the other hand, food waste, which is more common in high-income countries and urban societies, occurs during the later stages of the food supply chains (distribution and consumption stages) as a result of high level of discarded food (FAO 2016a).

According to the CFS's High-Level Panel of Experts (HLPE on Food Losses and Waste) in the context of sustainable food systems (HPLE 2014), the dryland-dominated Near East and North Africa Region (NENA region) has the highest percentage of cumulative food losses (36%) among all world regions, only matched by sub-Saharan Africa (Table 2.3). The highest level of losses is found at the early stages of the food supply chain. This high magnitude of loss contributes to reduced food availability, aggravated water scarcity, adverse environmental impacts and increased food imports, in this already highly import-dependent region.

Recommendation: Reducing food losses and waste would reduce both pressure on natural resources and the emission intensity from processing, conservation and transportation of more food quantities than needed.

Land Use Policies and Agreement Supporting Rural Communities from Encroachment of Large Farms and Land Grabbing

As discussed earlier, land use changes (in size, technology, farming systems, etc.) are leading to intensified conflicts between the settled farmers and the herders. Also government policies that favour external investors have marginalized the native and the tradition subsistence farmers and, in most cases, deprived them from their subsistence livelihoods.

On the positive side, several countries have signed to voluntary measures such as the following:

- *The Voluntary Guidelines on the Responsible Governance on Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT)* – FAO, 2012⁴
- *The Principle for Responsible Investment in Agriculture and Food Systems (PRAI)* –FAO, 2014

Use of Renewable Energy Sources

Combustion of fossil fuels is largely the cause of atmospheric concentration of carbon dioxide, the principal greenhouse gas. Overconsumption in order to provide energy for industry, domestic use and agriculture reached a level unequaled for more than 400,000 years (Climate Action Reserve). As a result, more of the sun's heat is being trapped near the earth's surface and gradually changing the earth's climate and contributing to global warming, extreme droughts and floods. Although most of the international community is aware of this, several geopolitical realities and financial obstacles are behind the reluctance and irresponsible performance of several governments in seeking alternative and renewable sources of energy. The brief discussion below is not an exhaustive account of the alternatives to fossil fuels but are meant to present a hint of what is in store.

There are at least ten major sources of renewable and environmentally friendly sources of energy that harness natural processes: *tidal power, wave power, solar power, wind power, hydroelectricity, radiant energy, geothermal power, biomass, compressed natural gas and nuclear power* (LISTVERSE 2009). Many dryland countries import oil or invest in developing hydroelectricity, the widely used source of renewable energy. However, the hydroelectric power has always been connected with social problem (forced displacement of people) or has proved to be a liability and environmental nightmare that many countries are now planning to get rid of before they became a national hazard. For example, dams cause water logging and siltation and account for loss of biodiversity by adversely affecting fish population and other aquatic organisms. Also hydropower plants fail to produce power when water levels go down or dry up because of extended droughts. When water is not available, the hydropower plants can't produce electricity and create problems of rehabilitation and related socio-economic problems. Dams drown sites of livelihood, mobilize or disintegrate local cultures and drown major historic sites such as the case of the Aswan Dam, the High Dam, Merowe Dam and the planned Dal, Kajbar and Esheraik dams along the Nile valley. Furthermore, dams increase seismicity (earthquake frequency) due to large volume of water impounded.

⁴FAO (2012). The Voluntary Guidelines on the Responsible Governance of Tenure (VGGT). The VGGT is an internationally negotiated document by the Committee on World Food Security (CFS) under the Food and Agriculture Organization of the UN (FAO) The VGGT were endorsed by The Committee on World Food Security (CFS) at a Special Session in May 2012. www.fao.org/fileadmin/user.../reu/.../vggt/VGGT_KG_en.pdf.

Not all renewable energy has problems equal to those generated by dams. Actually the majority, and specifically *solar and wind sources* of energy, are the most dominant in the dryland areas and have long-term and sustainable benefits if appropriately constructed and maintained. While there are many large-scale renewable energy projects and production, renewable technologies are also suited to small off-grid applications, sometimes in rural and remote areas, where energy is often crucial in human development.

The sun offers an ideal energy source, unlimited in supply, does not add to the earth's total heat burden and does not produce air and water pollutants. It is powerful alternative to fossil and nuclear fuels. Solar power is one of the fastest-growing energy sources, and so many new technologies are developing with rapid speed to attain more from sun's energy. Moreover, solar cells are becoming more productive, flexible, transportable and easier to instal.

Wind power has one of the lowest environmental impacts of all energy resources. At present wind produces only 1.5% of worldwide electricity, but it is growing fast. It achieved high level of penetration in many countries. The wind power electricity production in a few countries is phenomenal such as 19% of electricity production in Denmark, 11% in Spain and Portugal and 7% in Germany and Ireland.

2.3.1.2 Emerging Practices, Strategies and Polices to Enhance Investment in the Arid Areas

Adoption of Climate-Smart Technologies and Application Measures (Water and Land Management)

The smallholder crop and livestock agriculture systems in the dryland areas have been negatively impacted and, in most situations, decimated by climate variability, droughts and climate change. Cropping practices are mostly suboptimal, leading to poor crop growth, low vegetative cover, low crop yields and serious land degradation. In most dryland areas, especially in sub-Saharan Africa, climate change and variability have made drought and water scarcity common. However, it is now evident that the smallholder agricultural systems can be resilient to recurrent droughts and can adapt to climate change by adopting climate-smart practices, diversifying on-farm crop and livestock production and diversifying into off-farm income and employment especially for the women, youths and men. Furthermore, it has been demonstrated that such objectives cannot be achieved without sustainable management of land and water resources. Also it is now being fully embraced by policy-makers and development partners that such goals could not be achieved without improvements in infrastructure, extension, capacity development, climate information, market access, credit and social insurance that are needed to facilitate adaptation and diversification of smallholder livelihoods. The global community has shown commitment for achieving these objectives. There are at present instruments, though not comprehensive or sufficient, that allow funding major areas of investment in agriculture research, green agriculture and climate change adaptation. The

following techniques have proven success in improving small farming in the dry-land areas:

1. *Conservation agriculture (CA)* techniques are being used by farmers in the dry-land areas across the world with full support from the development partners and donors such as The World Bank, FAO, IFAD, AfDB and ADB. The CA techniques are developed by the CGIAR research centers, as well as university research programmes all over the world. The advantage of conservation agriculture summarized by the Conservation Agriculture: Global Research & Resources (Cornell University 2016) is in Box 2.7.

Box 2.7 Advantages of Conservation Agriculture

Conservation agriculture is generally a “win-win” situation for both farmers and the environment. Yet many people intimately involved with worldwide food production have been slow to recognize its many advantages and few consider it to be a viable alternative to conventional agricultural practices that are having obvious negative impact on the environment. Much of this has to do with the fact that conservation agriculture requires a new way of thinking about agricultural production in order to understand how one could possibly attain higher yields with less labour, less water and fewer chemical inputs. In spite of these challenges, conservation agriculture is spreading to farmers throughout the world as its benefits become more widely recognized by farmers, researchers, scientists and extensionists alike. Specifically, conservation agriculture (CA) increases the productivity of the following:

- *Land* – Conservation agriculture improves soil structure and protects the soil against erosion and nutrient losses by maintaining a permanent soil cover and minimizing soil disturbance. Furthermore, CA practices enhance soil organic matter (SOM) levels and nutrient availability by utilizing the previous crop residues or growing green manure/cover crops (GMCC's) and keeping these residues as a surface mulch rather than burning. Thus, arable land under CA is more productive for much longer periods of time.
- *Labour* – Because land under no till is not cleared before planting and involves less weeding and pest problems following the establishment of permanent soil cover/crop rotations, farmers in Ghana reported a 22% savings in labour associated with maize production. Similar reductions in labour requirements have been reported with no-till rice-wheat systems in South Asia and various CA technologies in South America. Much of the reduced labour comes from the absence of tillage operations under CA, which use up valuable labour days during the planting season.
- *Water* – Conservation agriculture requires significantly less water use due to increased infiltration and enhanced water holding capacity from crop

(continued)

residues left on the soil surface. Mulches also protect the soil surface from extreme temperatures and greatly reduce surface evaporation, which is particularly important in tropical and subtropical climates. In sub-Saharan Africa, as with other dryland regions, the benefits of conservation agriculture are most salient during drought years, when the risk of total crop failure is significantly reduced due to enhanced water use efficiency.

- *Nutrients* – Soil nutrient supplies and cycling are enhanced by the biochemical decomposition of organic crop residues at the soil surface that are also vital for feeding the soil microbes. While much of the nitrogen needs of primary food crops can be achieved by planting nitrogen-fixing legume species, other plant essential nutrients often must be supplemented by additional chemical and/or organic fertilizer inputs. In general, soil fertility is built up over time under conservation agriculture, and fewer fertilizer amendments are required to achieve optimal yields over time.
- *Soil biota* – Insect pests and other disease causing organisms are held in check by an abundant and diverse community of beneficial soil organisms, including predatory wasps, spiders, nematodes, springtails, mites and beneficial bacteria and fungi, among other species. Furthermore, the burrowing activity of earthworms and other fauna create tiny channels or pores in the soil that facilitate the exchange of water and gases and loosen the soil for enhanced root penetration.
- *Economic benefits* – Farmers using CA technologies typically report higher yields (up to 45–48% higher) with fewer water, fertilizer and labour inputs, thereby resulting in higher overall farm profits. In Paraguay, net farm income of no-till (NT) farming on large-scale commercial farms increased from \$23,467 to \$32,608 more than farms using conventional tillage over a 10-year period. The economic benefits of NT and other conservation agriculture technologies, more than any other factor, have led to widespread adoption among both large- and small-scale farmers throughout the world.
- *Environmental benefits* – Conservation agriculture represents an environmentally friendly set of technologies. Because it uses resources more efficiently than conventional agriculture, these resources become available for other uses, including conserving them for future generations. The significant reduction in fossil fuel use under no-till agriculture results in fewer greenhouse gases being emitted into the atmosphere and cleaner air in general. Reduced applications of agrochemicals under CA also significantly lessens pollution levels in air, soil and water.
- *Equity considerations* – Conservation agriculture also has the benefit of being accessible to many small-scale farmers who need to obtain the highest possible yields with limited land area and inputs. Perhaps the biggest obstacle thus far for the technology spreading to more small-scale farmers

(continued)

worldwide has been limited access in certain areas to certain specialized equipment and machinery, such as no-till planters. This problem can be remedied by available service providers renting equipment or undertaking conservation agriculture operations for farmers who would not otherwise have access to the needed equipment. Formulating policies that promote adoption of CA are also needed. As more and more small-scale farmers gain access to CA technologies, the system becomes much more “scale neutral.”

- *Active role for farmers* – As with any new agricultural technology, CA methods are most effective when used with skilful management and careful consideration of the many agroecological factors affecting production on any given farm or field. Rather than being a fixed technology to be adopted in blueprint-like fashion, CA should be seen as a set of sound agricultural principles and practices that can be applied either individually or together, based on resource availability and other factors. For this reason, farmers are encouraged to experiment with the methods and to evaluate the results for themselves – not just to “adopt” CA technologies. Selecting among different cover crop species, for example, needs to be determined in relation to particular agroecological conditions of the farm, including soil type, climate, topography as well as seed availability and what the primary function of the GMCC will be. Similarly, planting distances, irrigation requirements and the use of agrochemicals to control weeds and pests among other considerations must be decided based on what the farmer needs as well as the availability of these and other resources.

Source: Cornell University website (2016). Conservation Agriculture: Global Research & Resources

2. *No tillage* is a major aspect of CA but warrants detailed mention. Practices tried in many countries (e.g. ICARDA domain countries) include reduced tillage practices and breeding for adaptive crop and livestock species. Farmers and herders could be encouraged through also subsidized crop insurance schemes that could respond in a timely way to climate variability. However, zero tillage is a disregarded by many producers in developing countries because of conflicting demands on crop residues for animal feed or for household fuel. Also terraces or land levelling may prevent runoff (FAO, SOFA 2016).
3. *Watershed management* It has been proven that soils and water (surface and ground) resources can be better managed and sustained using soil water conservation (SWC) techniques (summarized in FAO 2008). The watershed approach encourages the promotion of cooperation between upstream and downstream

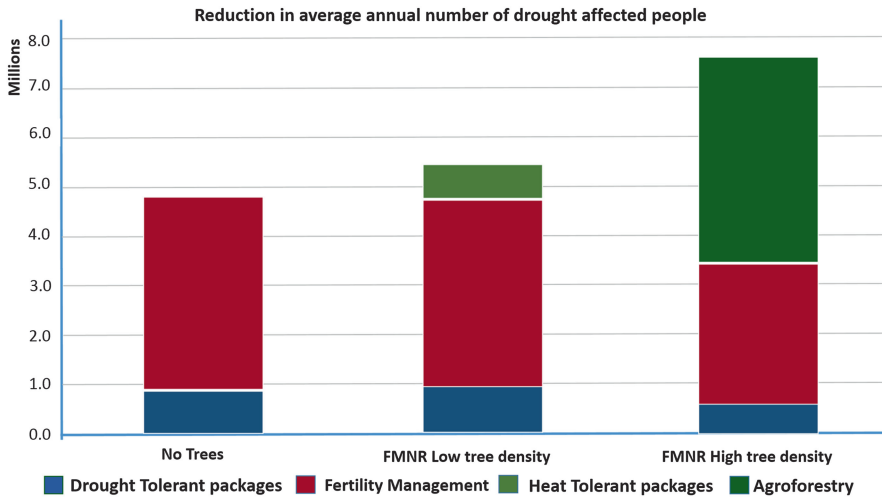


Fig. 2.1 Estimated reduction in the average annual number of drought-affected people resulting from FMNR and other technologies. *Source:* World Bank 2015 Africa Region Flagship Report: Enhancing Resilience in African Drylands. Towards a shared development agenda (Authors' estimates)

stakeholders – in an effort to minimize conflicts over land and water (FAO, SOFA 2016).

4. *Farmer-managed natural regeneration (FMNR)*: A number of modelling activities were carried out during the preparation of the Africa region flagship report “Enhancing Resilience in African Drylands: Toward a Shared Development Agenda” (World Bank 2015). The models sought either to add to the understanding of the problems or situations or to assess the impact of various approaches to mitigate drought shocks and to reduce conflicts. For example, the crop modelling helped provide orders of magnitude of the benefits of *farmer-managed natural regeneration* (FMNR) in terms of reduction of drought impacts. Impressive drought mitigation impact is possible by adding farmer-managed natural regeneration of native species to the other productivity-enhancing technologies (adoption of drought tolerant, fertility and heat-tolerant packages, agroforestry). Compared to no interventions scenario, in a group of ten countries in East and West Africa, the projected number of poor, drought-affected people living in drylands in 2030 fell by 13% with low-density tree systems and more than 50% with high-density tree systems (Fig. 2.1).
5. *CGIAR’s Research Program on Climate Change, Agriculture and Food Security (CCAFS)* – CGIAR (2012).⁵ Some examples are summarized in Box 2.8.

⁵ CGIAR, CCAFS. https://ccafs.cgiar.org/blog/future-farming-dry-lands-smart-solutions-climate-change#.WDcL_k3ymUl.

Box 2.8 Examples of Climate-Smart Farming

Niger: Planting of 200 million nitrogen-fixing trees such as *Acacia Senegal* and *Acacia seyal* has resulted in the transformation of 5 million hectares of once infertile land. The initiative has increased crop yields and fodder availability, benefiting 2.5 million farmers. Trees increase the carbon stored in the landscape, mitigating climate change.

Tunisia: Groups of “lead farmers” in Tunisia are being linked by mobile phone to crop and weather monitoring systems that issue alerts when irrigation is needed. The information can then be relayed to other producers.

North and sub-Saharan Africa: The use of different planting methods, high-yielding varieties, improved water management and integrated pest management in seven countries across North and sub-Saharan Africa, new approaches tested by national research and extension systems with ICARDA has produced a 22% increase in wheat yields for Egypt and a 58% increase in Sudan – based on actual farmer experiences (not trials).

Source: CGIAR. CCAFS https://ccafs.cgiar.org/blog/future-farming-dry-lands-smart-solutions-climate-change#.WDcL_k3ymUI

Adoption of Conflict-Sensitive Policies and Strategies

In response to the protracted droughts and the humanitarian crises they caused, the heads of state and governments of East Africa Community (EAC) and IGAD member states (*Djibouti, Eritrea, Kenya, Somalia, South Sudan, Sudan, Tanzania and Uganda*) held a summit meeting in Nairobi in 2011 that was mainly focused on the need for a strategy to address drought threats in a decisive and sustainable way. In response the Global Alliance for Action for Drought Resilience in the Horn of Africa was facilitated and funded by USAID through a technical consortium (TC) between FAO and the CGIAR with the involvement of other relevant research and academic (IGAD 2013a, b; FAO 2014a, b, c, d, e, f). Similarly 2012 drought-induced crises in the African Sahel lead to the OECD-facilitated and OECD-supported initiation of the Global Alliance for Resilience – Sahel and West Africa (AGIR) – (World Bank 2015).

To meet this challenge, the IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI) was launched in 2013. The IDDRSI succeeded in creating a strong political momentum and commitments by the member countries and the development partners and increased investments and spurred resource mobilization. Operational frameworks and programmatic implementation mechanisms that are providing strategic direction and the operational framework for resilience-enhancing policies and investments complement the IDDRSI strategy. The common architecture of the IDDRSI is based on six strategic priority areas (natural resource management, market access and trade, livelihood and basic services support, pastoral

disaster risk management, research and knowledge management and peace building and conflict resolution) that address drought resilience in a holistic manner and encompass policies and mechanisms supporting the adaptation of pastoralists and the small farmers/herders to drought shocks and uncertainties. The IDDRSI strategic framework is also aligned with the CAADP and with UN objectives to increase resilience of livelihoods to drought-triggered disasters.

Evolution of the Cross-Border Cluster Approach: A Tool for Regional and International Conflict Resolution, Early Warning and Response Mechanisms

The cross-border cluster approach is a very effective, though complicated, approach for managing conflict in the dryland areas particularly among the traditionally mobile pastoral and agro-pastoral communities (please refer to Boxes 2.5 and 2.6 above for illustrative explanations). The cluster approach can help in bridging the human development gap through specific investments projects through scaling up innovations that would enhance resilience and sustainability. These could include awareness building of the potential of these regions as well as their regional nature, early warning systems based on effective social and technological tools for measuring resilience and creating coping mechanism capable of overcoming and mitigating shocks.

Because of a multitude of geopolitical, social and climatic events, these cross-border areas are sites of conflict and competition for natural resources (specially grazing land and water). A good example presented in this chapter is the cluster approach that was developed by IGAD with the concerned member countries (Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda) and the donors. The approach was defined (Box 2.9) during resource mobilization for the drought-resilience projects that followed the development of IDDRSI. Resources for the abovementioned countries were provided by the World Bank, African Development Bank and Germany for the design and implementation of two cross-border programmes: Drought Resilience and Sustainable Livelihoods Program DRSLP and The Regional Drought Resilience Fund RDRF. FAO provided technical support throughout the preparation of IDDRSI and the development projects (FAO 2014a, b, c, d, e, f; IGAD 2015). The following are the major requirements/features/benefits of the cross-border cluster approaches:

- An important intervention in the cluster approach is to coordinate the stakeholders in order to exchange information effectively and to synchronize activities such as vaccination campaigns, surveillance and disease control.
- There is no cross-border solution without dialogue.
- Stakeholders on multiple levels need a voice to ensure that responsibilities for long-term resilience promotion are carried out.
- Investment need to be coordinated in order to facilitate the necessary dialogue and to avoid duplication and contradiction.

Box 2.9 Definitions of Cross-Border Cluster

There are two major but related definitions for the cluster

- *A geographic space cutting across a country border in which stakeholders aim to develop and implement coordinated investments to enhance resilience.*
- *A geographic space that cuts across multiple political–administrative units within the country and international borders, where a range of resources, services, cultural values are shared by pastoral and agro-pastoral communities, and in which stakeholders aim to develop and implement coordinated investment s to enhance resilience and sustainable development.*

Clusters are characterized by a set of unifying factors (e.g. social/ethnic/linguistic unity, complementary natural resources, infrastructure, trade) but also common challenges (e.g. droughts, insufficient access to water and pasture for grazing, resource conflicts). Clusters face challenges regarding natural resources (grazing land, water points), infrastructure (main road and feeder road local markets, internal and cross-border trade points), and services (veterinary and quarantine services).

Sources: IGAD and FAO

- The approach helps the countries harmonize their policies related to dryland communities.
- The governments, country partners, civil society organizations and development partners should participate actively in the dialogue.

Acceleration of African Agriculture Growth and Transformation

As discussed in the above section, a large part of the global funding and programmes addressing the vulnerability of agriculture in the dryland areas is allocated to Africa. Excluding deserts, 43 % of Africa land surface is dryland areas. Furthermore, the Horn of Africa and the Sahel are the most drought-prone regions of the world where most of the global drought disaster occur. According to the report, sub-Saharan Africa was responsible for 88% of the global conflict death toll between 1990 and 2007, in addition to over 9 million refugees and internally displaced people. Therefore, the progress in the goals set for the Comprehensive Africa Agriculture Development Programme (CAADP) as continent-wide agenda for the transformation of African agriculture, economy and society will have implication on global stability and sustainability. The African heads of state endorsed the CAADP in 2003 as a New Partnership for Africa's Development (NEPAD) programme with a vision for the restoration of agricultural growth, food security and rural development. The

CAADP introduces a new approach to development focusing on both achieving economic growth and poverty reduction, entails the participation of all stakeholders and promotes regional cooperation. The CAADP covers agriculture (crops, live-stock, fisheries and forestry), environment/climate change (resilience, mitigation, adaptation, adoption of innovations and new technologies), food and nutrition security, youth employment and gender mainstreaming. The CAADP's policy, planning and investment approaches are comprehensive, inclusive and multisectoral.

The CAADP's objectives are to achieve growth rates in the overall agriculture sector of minimum 6% per year in each African country. This was foreseen achievable by committing for agriculture at least 10% of government spending, developing dynamic regional markets and integrating farmers into those markets and achieving a more equitable distribution of wealth. This objective is foreseen to be achieved through measurable outcomes to be derived from four key investment priority areas: extending the area under sustainable land management and reliable water control systems; improving rural infrastructure and trade-related capacities for market access; increasing food supply, reducing hunger, and improving responses to food emergency crises; and improving agriculture research, technology dissemination and adoption.

Since 2003 most African countries developed their CAADP based National Agricultural Investment Plans (NAIPs) and a few are at present participating in the development and implementation of a second generation of NAIPs aiming to achieve further goals set in 2014 to guide African agriculture growth and transformation during the next 10 years (to 2025). The CAADP goals, and consequently the NAIPs and the Regional Agricultural Investment plans, are aligned with most of FAO's Strategic Objectives (FAO 2014a, b, c, d, e, f) and the Sustainable Development Goals (SDGs)⁶ particularly those targeting reduction of poverty, hunger, food insecurity and malnutrition combating impact of climate change and desertification and enhancing resilience of livelihoods to disasters (e.g. SDG 1, 2, 3, 13 and 15).

Enhancing Resilience to Drought Shocks: Example from Somalia

The drought emergency crises in the Horn of Africa attracted the attention of the governments and the development partners to seek alternatives to the unsustainable measures of emergency humanitarian relief and food distribution program. The tripartite strategy developed by FAO, WFP and UNICEF (2012) and adopted by the development partners during the Somalia drought crises (Sidahmed 2013) is an example of how a combination of interventions to improve the current livelihoods (dryland farming, pastoral herding), to strengthen safety nets and to develop new and alternative livelihoods is being tried (Box 2.10). For example, a strategy to galvanize collective efforts aiming at laying the foundations for stability. The declaration made at the Istanbul Conference (FAO 2012a, b) recognized the urgent need to enhance resilience of the Somali households and communities, through multi-year and sectoral investments suited to each geographic location within Somalia (Box 2.10).

⁶ UN (2015). On 25 September 2015, countries adopted a set of goals to *end poverty, protect the planet and ensure prosperity for all* as part of a new sustainable development agenda; <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>.

Box 2.10 The Building Blocks for Enhancing Resilience in Somalia

Strengthen productive sectors to enhance household income for the various livelihood types (pastoralism, agro pastoralism, farming, riverine, fishing and urban) through improved access of working households to productive assets, income diversification, intensification, enhanced technologies, employment opportunities, market systems and market information.

Enhance basic services to protect human capital access of men and women to *basic services* that enhance human capital (e.g. health, nutrition, education, sanitation, food and water safety and hygiene, adequate skill) and *support services* (extension, animal and plant health services and information and knowledge management for early warning and planning).

Promote safety nets to sustain the basic needs of the chronically destitute/at risk (for a minimum of social protection) entails moving beyond the discontinuous cycles of short-term assistance to approaches that build resilience by providing a predictable level of assistance to those suffering from long-term destitution as well as for households that are seasonally at risk on a recurrent basis

Sources: Sidahmed, A E June 2013. Somalia Country Programme Paper (CPP). Programming Framework IGAD Initiative for Drought disaster Resilience and Sustainability Initiative (IDDRSI) in the Horn of Africa (HoA). FAO Investment Centre Rome Italy

The Establishment of Family Farming Price Guarantee Programmes in Brazil

Management of drought shocks, that aim for more than humanitarian emergency rescue programmes, have proven long-lasting benefits to the vulnerable dryland farming and herding families. One successful example was achieved in Brazil under its *Bolsa Familia* (OECD-FAO 2015). The Family Farming Price Guarantee Program (PGPAF) is an insurance programme that provides discounts on credit contracts to offset drops in farm revenue owing to reductions in market prices or climate-induced crop losses. In addition, a harvest insurance fund specifically targets farmers in Brazil's semiarid region when drought causes severe crop losses for family farmers.

2.3.1.3 The Establishment of the Green Climate Fund

A major lesson learned over the past decades is the fact that climate change is a threat to the poor and the rich nations in the same manner that poverty is a threat to all. Also there is little disagreement that climate change is affecting agriculture and food security and putting millions of poor people (mainly small farmers and herders) at risk of hunger and poverty. This underscores the important role that agriculture could play as the primary investment area in the global response to

climate change. For such an interrelated undertaking, sustainable agriculture production and productivity (particularly of the poor rural communities e.g. small-holder agriculturalist and herders) would require adoption of a number of appropriate technologies and innovations such as: climate-smart agriculture practices, diversification of on-farm and off-farm income and sustainable management of water and land resources. However, these investments must be supported by improvements in infrastructure, extension, climate information, market access and credit and social insurance.

Therefore, the global community has increasingly understood the importance of tackling together hunger, poverty and climate change. One option, the Green Climate Fund (GCF) – a dedicated multilateral climate fund (FAO, SOFA 2016) – was established at the 16th Conference of Parties to the United Nations Framework Convention on Climate Change in 2010 (UNFCCC 2010), with a main objective of promoting low emission in agriculture (e.g. addressing emissions from land use change driven by agricultural expansion) and to help the vulnerable communities in the developing countries to adapt to the unavoidable impacts of climate change, while maintaining sustainable agricultural development.

The GCF responds to climate change threats by investing in low-emission and climate-resilient development programmes especially in sub-Saharan Africa, the most negatively impacted region of the world (deforestation, decline in water resources). For example, the common thematic areas of the GCF projects in Africa of relevance to drought management are *water and land resource management* (e.g. in Chad, Kenya, Burkina Faso, Morocco Tunisia, and Egypt), *sustainable catchment management* (e.g. in Uganda and Rwanda) and climate resilience of agro-sylvo pastoral ecosystems in the DRC. As of May 2016, pledges made to the GCF reached US\$10.3 billion, of which US\$9.9 billion has been signed over to the fund (FAO, SOFA 2016). This sum is expected to rise to at least US\$100 billion in annual climate finance to developing countries by 2020. FAO is accredited with the GCF as a grant-implementing entity for medium-sized projects (USD 50–250 million) with a medium level of environmental and social risk.

2.4 Summary and the Way Forward

2.4.1 Summary

Between 1.0 and 1.5 million of the world population live in fragile and conflict affected areas,⁷ of which a major part falls within the dryland areas. Although some progress was made in reducing onset of extensive famines and in spite of two

⁷Kimberly Flowers (2016). The 13th Annual George McGovern Lecture “Examining linkages: The nexus between food insecurity and political instability” 22 Nov 2016; Kimberly Flowers is the Director of the Global Food Security Project, Center for Strategic and International Studies (CSIS), USA.

decades of relatively stable food market, there are some very remarkably threatening food insecurity hotspots caused by protracted droughts and floods (e.g. Horn of Africa, South Asia, respectively), and civil wars such as Syria (which have turned in 5 years from producer and exporter of food to a food deficit country), South Sudan and Somalia.

The drought-related acute food shortage in the Sahel region of West Africa and the Horn of Africa have left about 18.7 million and 11.7 million people, respectively, in need of emergency assistance.

The potential impact of climate change on agriculture in sub-Saharan Africa, and especially the drier climates, will be negative and would enhance poverty, malnutrition and hunger. This is because the frequency of extremely dry and wet years will increase, thus disrupting agriculture production. Also forage production will decrease remarkably, particularly in the Sahel as a result of drought and range degradation.

2.4.2 The Way Forward

The global community has increasingly understood the importance of tackling together hunger, poverty and climate change. Major landmark agreements include the Paris Agreement to cap the limit of global warming to below 2.0 °C or even to 1.5°. Encouraging developments include commitment of the international community to continue the dialogue and focus on actions to achieve the goals of the Paris Agreement through sets of COPs starting with COP 22 in Morocco in November 2016. In Marrakech the heads of state, government and delegations called for the highest political commitment to combat climate change as an urgent priority, and the developed country partners affirmed a US\$100 billion mobilization goal in support of climate projects. In addition of commitments by the bilateral donors such as EC, DFID and USAID (e.g. the multibillion dollar Feed the Future Program), there are already committed global instruments such as the Green Climate Fund (GCF) – a dedicated multilateral climate fund – which was established at the 16th Conference of Parties to the United Nations Framework Convention on Climate Change in 2010, with a main objective of promoting low emission in agriculture (e.g. addressing emissions from land use change driven by agricultural expansion) and to help the vulnerable communities in the developing countries to adapt to the unavoidable impacts of climate change, while maintaining sustainable agricultural development.

2.4.3 Recommendations for Actions to Make Current Livelihoods More Resilient in the Drylands

Most of the summary recommendations below were derived from the analyses of the experiences in sub-Saharan African drylands. For example, the recent intensive study by a team from 16 international and regional institutions coordinated by the

World Bank and FAO (World Bank 2015). However, consideration and assessment of the validity of these recommendations to the developing country drylands areas were undertaken because of the global nature of the review as well as the global nature of the consensus in measures to address poverty, drought and climate change as extensively referenced in the text. The “research for development” recommendations were derived from global sources (CGIAR 2012).

2.4.3.1 Strategic Action Areas (SAA)

The strategic action areas listed below are adopted from the Implementation Strategy and Road Map (IS&RM) to achieve the 2025 vision on the Comprehensive Africa Agriculture Development Programme (CAADP). The action areas aim to operationalize the 2014 Declaration of the African Head of States and Governments into accelerate African agriculture growth and transformation of shared prosperity and improved livelihood.

Objective 1: Transformed agriculture and sustained inclusive growth

- Increase production and productivity
- Enhance market, trade and value chain
- Increase resilience of livelihoods and systems
- Strengthen governance of natural resources

Objective 2: Strengthened systemic capacity to implement and deliver results

- Strengthen capacities for planning
- Strengthen policies and institutions
- Strengthen leadership, coordination and partnerships
- Enhance skills, knowledge and agriculture education
- Strengthen data and statistics
- Institutionalize mutual accountability
- Increase public and private financing

2.4.3.2 Technical Action Areas (TAA)

1. Crop production

- Accelerate the rate of varietal turnover and increase availability of hybrids.
- Improve soil fertility management.
- Improve agricultural water management.
- Promote the development of irrigation, including both rehabilitation of existing capacity, as well as expansion, up to the viable potential (a max. of about 10 more million hectares), and focusing on small-scale systems, with good access to markets for cash crops.

2. Natural resource management

- Promote farmer-managed natural regeneration (FMNR) to establish a range of beneficial trees throughout the drylands.

- Invest in tree germplasm multiplication and promote planting of location-appropriate high-value species especially in dry subhumid areas.
- Develop value-added opportunities for tree products produced in the drylands.

3. *Livestock production*

- Increase production of meat, milk, and hides in drylands by developing sustainable delivery systems for animal health, promoting increased market integration and exploiting complementarities between drylands and higher rainfall areas.
 - In each country, public veterinary services should be strengthened for carrying out the public good services, in particular vaccination for the major contagious (transboundary) diseases, quarantine and enforcement of sanitary standards, while at the same time enabling the development of a private network of professional and para-professional animal health providers for clinical services.
 - Animal health improvements should be accompanied with increasing access to feed (water development in the arid zone and fodder crop promotion in the semiarid/subhumid zones).
 - Further increase in production can be achieved by expanding the complementarity between the drylands and nondry ecosystems by promoting stratification, with the drylands supplying younger and better quality stock for fattening in the higher rainfall areas.
- Enhance the mobility of herds by expanding and ensuring adequate and equitable year-round access to grazing and water and by improving security in pastoral zones. The following interventions/approaches contribute to improved mobility have the potential to improve significantly the performance of livestock systems in the drylands:
 - Development of water resources to allow better access to underexploited rangelands or the organization of feed markets and feed transport. This would cover water development in underserved areas in the arid zones, clearly marked corridors between the arid and subhumid zones and reserved access to dry season grazing areas.
 - Improvement of land use planning to facilitate movement of herds and flocks (e.g. through designation of dedicated migration corridors and dry season grazing areas).
 - Engagement in comprehensive and fully inclusive dialogue with the pastoralist on priorities in development, restoring trust and convincing the pastoral population to become partners in improving security.
 - Policies that promote a more equitable access to grazing (preferential allocation of user rights to groups of smallholders, progressive taxation or grazing fees).
 - Mobility can further be increased with regional integration through harmonization of sanitary standards and the removal of informal and unnecessary administrative border procedures.

- Develop Livestock Early Warning Systems (LEWSs) and early response systems to reduce the adverse impacts of shocks. There are a number of early warning systems using modern technology that can be introduced or strengthened, the key focus being in their sustainability. There is also a number of early response actions such as subsidised destocking at the onset of drought, provision of additional feed supplies, etc. The focus should be on cost-efficiency.
 - Public-private partnerships (PPPs) are needed to develop stratification, with the public sector (Ministries of Infrastructure, Commerce) having the prime responsibility for the infrastructure (roads, markets) and the private sector for market development
 - Identify additional and alternative livelihood strategies, including through systems of payment for environmental services, through value adding in the value chain (fattening, processing, local leather industries) and through credit and education, in particular vocational skill training, employment opportunities need to be created outside the livestock sector.
4. *Social protection*
- Establish and gradually expand the coverage of national adaptive safety net programmes that promote resilience of the poorest.
 - Use social protection programmes to build capacity of vulnerable households to climb out of poverty but maintain the ability to provide humanitarian assistance in the short run.
 - Respond to emergencies by scaling up existing programmes, rather than relying on appeals for humanitarian assistance.
 - Tailor social protection programmes to address the unique circumstances of dryland populations.

Research for Development

1. Crop yield-increasing technology packages, which include the use of tied ridging for water conservation, improved crop varieties, use of manure and micro-dosing.
2. Training farmers in soil conservation terracing techniques.
3. Employing farming methods that adapt to changing climatic conditions and boost productivity while maintaining the sustainability of natural resources.
4. Combining the principles of Integrated Soil Fertility Management (ISFM), conservation agriculture and water management.
5. Large-scale testing of research developed disease-resistant, high temperature-tolerant varieties that are also fast growing.
6. Science and technology parks fostering innovative entrepreneurship in the Asia Pacific region
7. Community-based organizations trained and facilitated to promote climate-smart agriculture.

References

- AfDB, Feed Africa: strategy for agricultural transformation in Africa 2016–2026. (2016). http://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Feed_Africa_Strategy_for_Agricultural_Transformation_in_Africa_2016-2025.pdf
- Agriculture and Rural Development Strategy towards 2040 Investment Plan, FAO Strategy report TCIC. (2016–2020)
- CFS, Framework for action for food security and nutrition in protracted crises (FFA). (2015). www.fao.org/cfs
- CGIAR, *CRP Programme- Integrated Agricultural Production Systems for Improved Food Security and Livelihoods in Dry Areas* (“Dryland Systems”). Inception Phase Report. CRP Programme. (2012). www.cgiar.org
- CGIAR, CCAFS, (n.d.). https://ccafs.cgiar.org/blog/future-farming-dry-lands-smart-solutions-climate-change#.WDcL_k3ymUI
- Climate Action Reserve, Climate action facts. (n.d.). <http://www.climateactionreserve.org/resources/climate-change-facts/>. Last visit 21 Nov 2016
- Cornell University website, Conservation agriculture: global research & resources. (2016). <http://conservationagriculture.mannlib.cornell.edu/pages/aboutca/advantages.html>
- S. Devereux, *Vulnerable livelihoods in Somali Region, Ethiopia*, ODI Research Report No. 57 (Overseas Development Institute, Sussex, 2006)
- EM-DAT, The International Disaster Database, maintained by the Center for Research on the Epidemiology of Disasters (CRED), Université Catholique de Louvain. (n.d.). (www.emdat.be)
- FAO, Chapter 1: Drylands, people and land use, in *Waters and Cereals in Drylands* (2008). <http://www.fao.org/docrep/012/i0372e/i0372e01.pdf>
- FAO, The Voluntary Guidelines on the Responsible Governance of Tenure (VGGT). The VGGT is an internationally negotiated document by the Committee on World Food Security (CFS) under the Food and Agriculture Organization of the UN (FAO) The VGGT were endorsed by The Committee on World Food Security (CFS) at a Special Session in May 2012. (2012a). http://www.fao.org/fileadmin/user_upload/reu/europe/documents/Events2015/vgg/VGGT_KG_en.pdf
- FAO, Proceedings of Istanbul conference-partnership for resilience. (2012b). May 2012
- FAO, FAO new strategic framework and the role of statistics. – AFCAS 23, 2013. (2014a) http://www.fao.org/fileadmin/templates/ess/documents/afcas23/Presentations/AFCAS_2_StrategicFramework_JS.pdf
- FAO, The Technical Consortium (TC) for building resilience to drought in the Horn of Africa – completion report FAO, CGIAR and ILLRI. (2014b)
- FAO, The principles for responsible investment in agriculture and food systems (PRAI) was endorsed by CFS endorsed on October 15th, 2014. (2014c)
- FAO, The technical consortium for building resilience to drought in the Horn of Africa. USAID, FAO and CGIAR Completion Report May 2014. (2014d)
- FAO, Special report: FAO/GIEWS livestock and market assessment mission to Karamoja Region, Uganda April 2014 1367 4E/1/03.14. (2014e). http://resilience.igad.int/attachments/article/283/160804_Uganda
- FAO, Pasquale Steduto. The regional initiative on water scarcity. National Drought management Policy workshop. (2014f)
- FAO, Commission on genetic resources for Food and Agriculture FAO. (2015d). Website: <http://www.fao.org/nr/cgrfa/en/>
- FAO, RNE. Ahmed E. Sidahmed, Brian Perry and Nancy Morgan. The contribution of livestock to food security in the Neareast and North Africa Region. Primary background paper for the Discussion Paper NERC/16/4/ Rev.2 33rd Session of FAO Regional Conference Rome, Italy May 2016. (2016a)

- FAO, Ahmed E Sidahmed working paper: NATIONAL PROGRAMME: sustainable livestock development for food security in Oman, in *Guidelines for Land Use System Mapping*, Technical Report # 8, ed. by ed. by Sustainable LADA, (FAO, Rome, 2016b)
- FAO, SOFA, The state of food and agriculture; climate change, Agriculture and Food Security. (2016)
- FAO, UNICEF and WFP Somalia, A strategy for enhancing resilience in Somalia. (2012)
- Kimberly Flowers, The 13th annual George McGovern lecture "Examining linkages: The nexus between food insecurity and political instability". 22 Nov 2016 Kimberly Flowers is the Director of the Global Food Security Project, Center for Strategic and International Studies (CSIS); USA. (2016)
- A.K. Fosu, Inequality and the impact of growth on poverty: Comparative evidence for Sub-Saharan Africa. *J. Dev. Stud.* **45**(5), 726–745 (2009)
- FSNAU, Technical series report no VI 36 March 4, 2011. (2011)
- D. Headey, A.S. Taffese, *Enhancing Resilience in the Horn of Africa: An Exploration into Alternative Investment Options*, IFPRI Discussion paper 01176 (IFPRI, Washington, DC, 2012)
- HLPE, Report on sustainable agricultural development for food security and nutrition: what roles for livestock? Extract from the Report: Summary and Recommendations (23 June 2016). (2016). http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_S_and_R/HLPE_2016_Sust-Agr-Dev-FSN-Livestock_S-R_EN.pdf
- A. Hosseinizadeh et al., Impact of climate change on the severity, duration, and frequency of drought in a semi-arid agricultural basin. *Geoenviron. Disaster.* 2015 **2**, 23 (2015)
- HPLP, Food losses and waste in the context of sustainable food systems, a report by the – The High Level Panel on Food Security and Nutrition (HPLP). (2014)
- IFPRI, Derek Headey, A.D Taffesse and L You. Enhancing resilience in the Horn of Africa: an exploration into alternative investment options. IFPRI Discussion paper 01176. (2012)
- IGAD, IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI). (2013a)
- IGAD, The Intergovernmental Authority for Development (IGAD) Drought Disaster Resilience and Sustainability Initiative (IDDRSI). (2013b)
- IGAD, IDDRSI. Cluster approach for cross border cooperation and investments to strengthen drought resilience in IGAD Region. (2015)
- IGAD & FAO, IGAD Regional Agriculture Investment Plan (IGAD-RAIP). (2016)
- ILRI, UN endorses recommendations on sustainable agricultural development for food security and nutrition, including the role of livestock; Round Table of the Committee on World Food Security (CFS), meeting in Rome on 17 Oct 2016. (2016). <https://news.ilri.org/2016/10/20/un-endorses-recommendations-on-sustainable-agricultural-development-for-food-security-and-nutrition-including-the-role-of-livestock/>
- IOA, Food insecurity and malnutrition in Africa: current trends, causes and consequences CONSULTANCY AFRICA INTELLIGENCE (CAI) Published by In *One Africa*, on 19 Sep 2012. (2012). <https://polity.org.za>
- IPCC, *Climate Change 2007: Synthesis Report. International Panel on Climate Change Report* (Cambridge University Press, Cambridge, UK, 2007)
- IUCN, IUCN_ESARO dryland situation analysis IUCN Eastern and Southern Africa Regional Office (ESARO). (2010). Jonathan.davies@iucn.org
- LADA, *Guidelines for Land Use Systems Mapping. Technical Repoer #8* (FAO, Rome, 2008)
- M. Lesnoff, C. Corniaux, P. Hiernaux, Sensitivity analysis of the recovery dynamics of a cattle population following drought in Sahel. *Ecol. Model.* **232**(2012), 28–39 (2012)
- LISTVERSE, Top 10 renewable energy sources. Listserve Staff May 1, 2009. (2009). <http://list-verse.com/2009/05/01/top-10-renewable-energy-sources/>
- A. Loukas, L. Vasiliades, J. Tzabiras, Climate change effects on drought severity. *Adv. Geosci.* **17**, 23–29 (2008.). 2008 www.adv-geosci.net/17/23/2008/
- MCI, Multiple cropping Intensity is the sum of area harvested for different crops during the year divided by the total harvested land). (n.d.)

- Middleton, Thomas, The world atlas of desertification millennium ecosystem assessment (2005a). Climate change. Chapter 13, in *Ecosystems and Human Wellbeing: Current State and Trends, Volume 1*. (Island Press, Arnold, London, 1997)
- Millennium Ecosystem Assessment, *Chapter 22 Drylands Systems: Ecosystems and Human Wellbeing: Volume 1. Current State and Trends* (Island Press, Washington, DC, 2005.) <http://www.millenniumassessment.org/en/Global.html>
- OECD, Agricultural outlook 2009–2018. (2009)
- OECD-FAO, OECD-FAO agricultural outlook 2015–2024. (2015)
- OXFAM, (2012)
- Practical Action.Org, (n.d.). <http://practicalaction.org/drought-resilience-in-karamoja-1--practicalaction.org>
- I. Rodríguez-Iturbe, A. Porporato, *Ecohydrology of Water-Controlled Ecosystems: Soil Moisture and Plant Dynamics*. (Cambridge University Press, Cambridge UK, 2004)
- N. Stern, *The Stern Review on the Economics of Climate Change* (Cambridge University Press, Cambridge, 2006)
- N. Stern, *The Economics of Climate Change* (Cambridge University Press, Cambridge, UK, 2007)
- Summit, The Nairobi strategy: enhanced partnership to EDE. Adopted at the Summit on HoA Crisis. 9 Sept 2011. (2011)
- The Economist, Food Loss and its interaction with food security. A Special Report by the Economist Intelligence Unit. (2014).
- The Global Agenda for Sustainable Livestock, (n.d.). <http://www.livestockdialogue.org/>
- UN, Global drylands: A UN system-wide response first published in October 2011 by the United Nations Environment Management Group. (2011). http://www.unccd.int/Lists/SiteDocumentLibrary/Publications/Global_Drylands_Full_Report.pdf
- UN, On September 25th 2015, countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. (2015). <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>
- UNCCD, (n.d.). <http://www.unccd.int/en/Pages/default.aspx>
- UNFCCC, *United Nations framework convention on climate change. (COP 16)*. (2010)
- UNFCCC, Conference of parties 21 (COP 21). (2015). https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf
- UNFCCC, Marrakech partnership for global CC and Marrakech action proclamation. (2016). http://www.cop22-morocco.com/COP22_FINAL
- R.P. White, An ecosystems approach to drylands: building support for new development policies WRI.2002. (2002). <http://summit.wri.org/publication/ecosystem-approach-drylands-building-support-new-development-policies>
- World Bank, Africa region flagship report: enhancing resilience in African drylands: toward a shared development agenda. (2015)
- S.A. Woznicki, A.P. Nejadhashemi, M. Parsinejad, Climate change and irrigation demand: uncertainty and adaptation. *J. Hydrol. Reg. Stud.* **3**, 247–264 (2015)

Climate Variability Impacts on Land Use and Livelihoods
in Drylands

GAUR, M.; Squires, V.R. (Eds.)

2018, XXVI, 348 p. 49 illus., 43 illus. in color., Hardcover

ISBN: 978-3-319-56680-1