Chapter 9
Overview of Ecosystem-Based Approaches to Drought Risk Reduction Targeting Small-Scale Farmers in Sub-Saharan Africa

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Abstract Rain-fed agriculture in Sub-Saharan Africa (SSA) provides major but highly climate-dependent sources of livelihoods. Recurrent dry spells and droughts can impact SSA's agro-ecosystems in multiple ways, negatively affecting local social-ecological systems (SES). Droughts not only destroy crops and livestock and degrade natural resources but also impact a large variety of ecosystem services. However, ecosystems can also frequently be powerful agents for drought mitigation and resilient livelihoods. Ecosystem-based approaches mitigate drought impacts while providing multiple co-benefits which contribute to poverty alleviation and sustainable development, food security, biodiversity conservation, carbon sequestration and livelihood resilience. In drought risk management, ecosystem-based solutions have always been important, even if not explicitly acknowledged as such. Based on available literature, this chapter provides an overview of approaches for drought risk reduction in SSA in the context of ecosystem-based disaster risk reduction (Eco-DRR) and ecosystem-based adaptation (EbA). Using selected criteria, the review found many types of approaches, which strengthen functionality of the ecosystem and offer substantial environmental and socio-economic benefits, and thus help to mitigate drought impacts. More information on the limits of these approaches is needed in order to integrate them effectively into Eco-DRR and EbA programmes and complement them with more traditional disaster risk reduction strategies.

Keywords Drylands • Agro-ecosystems • Ecosystem services • Ecosystem-based disaster risk reduction (Eco-DRR) • Ecosystem-based adaptation (EbA)

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9.1 Introduction

A high degree of climatic and seasonal variability and recurrent extreme events such as droughts and floods are typical in Sub-Saharan African (SSA) drylands. Climatic hazards and dependency on rain-fed agriculture, together with socio-economic and environmental specificities of the region, make SSA's drylands highly vulnerable to the impacts of climate change (Niang et al. 2014). SSA's limited infrastructural development, low levels of per capita income, mostly subsidence-based rural population, and partial reliance on international food aid and disaster relief weaken the coping and adaptive capacities of social-ecological systems (SES)[1] (Benson and Clay 1998; Shiferaw and Okello 2011). In addition, land in SSA is often characterized by low inherent soil fertility, a poor capacity of most soils to retain moisture, and widespread soil degradation (Lahmar et al. 2012). This predisposition, together with population growth, high poverty rates, and a lack of capacity to invest in more sustainable agricultural practices are important factors that contribute to increasing land degradation (Holden and Binswanger 1998; Shiferaw and Okello 2011; Shiferaw et al. 2014). As a result, small-scale farmers find themselves confronted with the twin problems of drought and desertification, which are intrinsically linked (Falkenmark and Rockström 2008). In this context, there is an urgent need to mitigate drought impacts through adaptation processes which go hand in hand with economic development programs, improved food security, poverty reduction initiatives and sustainable environmental management.

The role of ecosystems in climate change adaptation (CCA) and disaster risk reduction (DRR) is increasingly acknowledged (e.g., Colls et al. 2009; Sudmeier-Rieux 2010; Estrella and Saalismaa 2013; Niang et al. 2014) and a growing body of literature and practical applications exist for numerous hazard contexts and under diverse socio-economic conditions. While ecosystem-based approaches for e.g. coastal hazards, river floods or landslides are well established, drought as a slow onset hazard is still under-represented in the discourse around Eco-DRR. This is starting to change as, for example, the theme of the 2014 World Day to Combat Desertification focused on ecosystem-based adaptation, emphasizing the importance of mainstreaming climate change adaptation into sustainable land management.

It is important to note that in the context of droughts, most mitigation[2] strategies, particularly those developed traditionally by small-scale farmers, are ecosystem-

[1]A system that includes societal (human) and ecological (biophysical) subsystems in mutual interaction (Gallopin 2006:294).

[2]Drought mitigation in the disaster risk reduction community is usually understood as a set of programs, measures and actions, which are undertaken in advance of a drought event in order to reduce the expected impacts of a drought and facilitate recovery. Mitigation includes proactive elements of drought preparedness. The term "drought mitigation" therefore corresponds to the term "adaptation" in the climate change community. Drought mitigation does not address the reduction of greenhouse gas emissions as usually associated with the term "mitigation" in a climate change context (Wilhite et al. 2014; WMO and GWP 2014).

based (Estrella et al. 2013). Locally-adapted, sustainable agricultural practices and strategies that strengthen ecosystem functioning exist in order to address challenges such as land degradation, food insecurity and a lack of access to agricultural inputs (Liniger et al. 2011; Jones et al. 2012; Munang et al. 2014). These have the potential to help reduce the susceptibility of the agro-ecosystem (croplands, rangelands, agro-forests, etc.) to droughts, increase preparedness and spread drought risks through diversification of agricultural production. Thus, they can contribute to healthier, more resilient ecosystems which produce a wide variety of ecosystem services. In such SES, the capacity of nature is used to buffer farmers and communities against the impacts of climate change and natural hazards. Additionally, the provision of a wider variety of ecosystem services results in many social, economic and cultural co-benefits which help to increase the resilience of SES facing climatic variability (Doswald and Estrella 2015).

This chapter aims to provide an overview of ecosystem-based approaches used mainly for dryland agriculture in SSA and discusses their suitability to support CCA and DRR objectives. To undertake this overview of ecosystem-based approaches to drought mitigation, we followed the definitions of Eco-DRR and EbA as outlined in Chap. 1, and adapted them to the drought context. This resulted in some key criteria for identifying suitable ecosystem-based approaches.

In order to collect the relevant literature on ecosystem-based approaches we draw on the review of Doswald et al. (2014) on EbA.[3] From the list of publications these authors used for the review, we selected all papers dealing with drought or rainfall variability focusing on SSA drylands and agricultural management and added more recent publications (2012–2014) through Scopus and Google Scholar searches. This allowed us to include a large number of papers, but because there are numerous concepts and approaches – that sometimes overlap – the overview of approaches is not fully exhaustive. The review, however, provides insights into the main and more common ecosystem-based approaches and agricultural techniques that can be used as part of EbA/Eco-DRR in the context of droughts.

The chapter starts by linking the concepts of Eco-DRR and EbA to the characteristics and impacts of droughts. From the definitions and conceptualizations around EbA and Eco-DRR (Chap. 1) we developed criteria described in Box 9.1 to identify suitable approaches and agricultural techniques. These approaches and techniques can be considered to be ecosystem-based, while at the same time they reduce drought risks and facilitate CCA. The key environmental, social and economic benefits, which contribute to greater livelihood resilience, are summarized. Furthermore, important drawbacks that may hinder application, as observed in the scientific and applied literature, are also highlighted. We also discuss to what extent the approaches help to solve multiple goals, operate at multiple scales and are locally adapted. The chapter concludes with a summary of the advantages of applying an ecosystem-based approach to drought risk reduction and boosting adaptation in SSA, but also points to current knowledge gaps.

[3]The procedure for identifying ecosystem-based adaptation measures for the review is described in Munroe et al. (2012).

Box 9.1 Criteria for Identifying Suitable Approaches and Agricultural Techniques for Ecosystem-Based Approaches Addressing Droughts
Approaches addressing droughts were characterised as suitable when they:

- Strengthen functionality of the ecosystem and use natural processes to provide multiple services;
- Provide drought mitigation (strengthening of regulating services of the ecosystem);
- Generate social, economic and cultural co-benefits. Through the improved functionality of ecosystems, ecosystem services and biodiversity are improved/maintained leading to multiple co-benefits- (e.g. improved yields, empowerment of marginalized groups, cultural value of diverse and healthy agricultural landscapes, etc.);
- Address multiple goals, e.g. minimize trade-offs and maximize benefits with development objectives (Andrade et al. 2011);
- Are applicable at multiple scales;
- Combine different sources of knowledge to generate locally adapted and well-negotiated approaches.

9.2 Linking Drought Risk Reduction to the Principles of Ecosystem-Based Approaches

In order to identify ecosystem-based approaches to reduce drought risks, this section first sheds light on the specific characteristics of droughts as slow-onset hazards and their major impacts on the ecosystem services provided by agro-ecosystems. Based on this background, principles of ecosystem-based approaches in a drought context are derived which are then used for the identification of approaches suitable to reduce drought risks.

9.2.1 Droughts and Their Impacts on Agro-Ecosystems

A drought is broadly defined as "*sustained, extended deficiency in precipitation*" (WMO 1986:2), or more specifically when "*precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems*" (UNCCD 2012a:1).[4] Generally, droughts are divided into four classes with increasing focus on the impact on SES (Wilhite and Glantz 1985):

[4]While insufficient rainfall is the primary cause of drought, this often goes together with increased potential evapotranspiration (IPCC 2012).

- **Meteorological drought**: when precipitation is lower than the long-term normal for a prolonged period.
- **Agricultural drought:** when there is insufficient soil moisture to meet the needs of a particular crop at a particular time.[5]
- **Hydrological drought**: when deficiencies occur in surface and subsurface water supplies.
- **Socio-economic drought**: when human activities are affected by reduced precipitation and related water availability. This form of drought associates human activities with elements of meteorological, agricultural, and hydrological drought and becomes evident when drought affects health, the well-being and quality of life of the population.

As these categories only broadly identify the respective drought types in agro-ecosystems, useful guidance can be taken from Rockström (2003), who refers to a meteorological drought as: insufficient rainfall to generate a harvest and seasonal rainfall which differs from long-term seasonal average.

SSA is characterized by seasonal rainfall patterns and rain-fed agriculture, thus timing of agricultural activities with respect to rainfall is critical. Dry spells are different from droughts, as they describe rainfall deficits over a period of several weeks during the agricultural production period (Rockström 2003) and are forecasted to intensify in East and southern Africa in the future (Niang et al. 2014:1206). West Africa shows increased drought and flood risks towards the late 21 century (Sylla et al. 2015). This review therefore targets both agricultural droughts and dry spells in the general context of climate variability.

The impact of any type of drought or dry spell is very much dependent on its length, timing and frequency, in addition to its severity, intensity, magnitude and areal extent (see e.g., Kallis 2008), and simultaneously on the vulnerability of exposed systems. Hence droughts/dry spells can impact a range of ecosystem services and reduce the capacity of agro-ecosystems to provide the benefits on which people depend. They can negatively impact provisioning services, resulting in reduced productivity of agro-ecosystems and reduced availability of fresh water (quantity and quality). They affect services that regulate the quality and quantity of water and soil, habitat services, as well as cultural services such as spiritual and religious values or cultural heritage. They can also negatively impact biodiversity and increase the likelihood of other, potentially hazardous events, such as wildfires.[6]

For agricultural droughts, the distribution of rainfall in relation to crop requirements matters more than total seasonal rainfall. The impact of agricultural droughts and dry spells depends very much on critical plant growth stages. Plants which have already been impacted by previous water shortages show a reduced capacity to take

[5]Also called "*soil moisture drought*" to refer to the fact that soil moisture deficits have wider effects than only those on the agro-ecosystem (IPCC 2012).

[6]Assessments of the full range of ecosystem services that are impacted by droughts and of interactions with the social system are rare (see e.g. Banerjee et al. (2013) for an example).

up water in the root zone (Falkenmark and Rockström 2008). Soil conditions, such as water holding capacity and water infiltration, have an impact on the manifestation of an agricultural drought, as they directly affect soil moisture content. Plant conditions, in particular water uptake capacity, further determine the degree of plant water stress and eventually yield reductions.

In order to mitigate the impacts of agricultural droughts and dry spells, the most direct entry point is an integrated agricultural management of water, soils and crops. Falkenmark and Rockström (2008) state that agricultural droughts/dry spells can be strongly influenced by existing management practices related to water, soils and crops. Building resilience to droughts therefore depends on increasing the ability to implement these management practices optimally for drought risk reduction. This is a crucial angle for ecosystem-based approaches to address. Approaches that strengthen resilience to droughts need to reduce the susceptibility of the SES to drought impacts, for instance through improving the water holding capacity of soils, or through crop diversification to balance crop water requirements. Such measures can simultaneously improve the resilience and sustainability of rural livelihoods, for example through increased yields, income, and food stocks, and thus reduce the need for migration.

9.2.2 Principles of Ecosystem-Based Approaches for Drought Risk Reduction

Social and ecological systems are not just linked but are interconnected and co-evolving across spatial and temporal scales (Stockholm Resilience Center 2007). Accordingly, Eco-DRR and EbA approaches should be implemented as integrated, holistic and interdisciplinary approaches recognizing these interconnectivities between and within systems (Sudmeier-Rieux 2010; Jones et al. 2012; Munang et al. 2014). EbA builds on the links between climate change, biodiversity, ecosystem services and sustainable resource management in order to increase the resilience[7] of livelihoods climate change impacts. Eco-DRR similarly aims for sustainable development and disaster resilience, based on managing, restoring and conserving ecosystems. Both emphasize the use of biodiversity and ecosystem services in a sustainable way (see Chap. 1 and the discussion on ecosystem-based DRR and CCA) and refer to the restoration of degraded/transformed agro-systems. The articulation of ecosystem services can be useful in implementing an ecosystem-based approach because it allows all the flows of services from the ecosystem to be captured. This provides the basis for them to be managed in such a way that they provide the greatest benefit to

[7]Resilience: "*The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation*" (IPCC 2014:5).

humans whilst still ensuring ecosystem function. Importantly, both Eco-DRR and EbA stress the generation of economic, social and environmental co-benefits when compared to other, more conventional DRR and CCA measures (e.g., dams and dikes). The creation of co-benefits contributes to improving the resilience of the SES (see Box 9.1).[8]

There are a number of approaches that try to explicitly link multiple objectives in an integrated way in order to tackle climatic, environmental, social and economic challenges (UNDP 2011). Review papers on EbA and Eco-DRR stress that many such approaches are not completely new ideas, but already exist in traditional natural resources management and ecosystem restoration efforts, or can be part of DRR or CCA measures (Munroe et al. 2012; Estrella and Saalismaa 2013).

As mentioned in Box 9.1, when considering ecosystem-based approaches for DRR and CCA, taking a landscape perspective is critical. Typically, decisions on land use changes need to be informed by the flow of ecosystem services at the landscape scale (Vignola et al. 2009). The multifunctional landscapes approach supports the idea that ecosystem service flows need to be managed at multiple scales and integrate ecological principles at the field, farm and landscape scales (McGranahan 2014). The ecosystem-based approaches described in Sect. 9.3 should be seen in the context of "*people-centered landscape approaches to environmental management*" as defined by Sayer et al. (2013:8349), particularly when several approaches are being implemented in a landscape, addressing both livelihoods, economic development and conservation goals. Ecosystem-based approaches are not only about the measures themselves, but also how to best combine them at the field, farm and landscape levels to maximise DRR, CCA and development objectives. Some of the approaches discussed in the next section target the landscape level, while others are farm or field level, but can be part of landscape level approaches.

9.3 Ecosystem-Based Approaches to Drought Risk Reduction in Sub-Saharan Africa

As the impacts of droughts are manifold, so are the coping and adaptation strategies of small-scale farmers in the drylands of SSA. A recent overview by Shiferaw et al. (2014) summarises response strategies of rural households in SSA and discusses key technological, institutional and policy strategies for drought mitigation and adaptation, such as improved crop varieties, improved soil fertility and water management, and index-based insurances. Here, we focus only on ecosystem-based approaches which have a direct link to agricultural activities, but of course these need to be complemented by integrated technological, institutional and political measures and include governance and management aspects (see

[8]For a closer comparison of EbA and Eco-DRR see Doswald and Estrella (2015).

e.g. Andrade et al. 2011, for the latter). Among them, there are several scientific and applied literature approaches which address how to increase water efficiency and agricultural productivity while reducing land degradation. These techniques are all explicitly or implictly suitable for drought mitigation.

In a drought context, existing publications on EbA and Eco-DRR refer to the sustainable management of grasslands and rangelands (UNCCD 2012c); agricultural practices that maintain vegetation cover, conserve soils and restore natural vegetation; shelter belts and green belts (Estrella and Saalismaa 2013); water harvesting and conservation farming (Colls et al. 2009); protected area management (e.g., Dudley et al. 2015) and others.

To extend this list and make it more specific as to how many of these approaches contribute to the principles of Eco-DRR/EbA, we compiled additional information through the literature review. The following section provides an overview of (existing) approaches which were identified based on our set criteria (Box 9.1). But it cannot provide a comprehensive list of all existing approaches and techniques.

We begin by presenting the broader classes of approaches that go beyond addressing purely agricultural goals. These approaches entail multiple strategies and agricultural techniques, of which some or all can be considered as ecosystem-based and address multiple goals tackling the links between water, land, and biota. Aiming for sustainability and resilience, some approaches explicitly refer to being holistic, by calling for collaboration, flexible management, local knowledge and participation at multiple geographical scales and hence overlap with our set criteria (Box 9.1).

After discussing the broader classes of approaches, more narrow or targeted approaches and agricultural techniques are described. The length of description for each approach reflects the amount of available literature per approach. Table 9.1 gives a systematic overview of goals, environmental and social benefits, scale issues and highlights drawbacks that may hinder the application of these more targeted tools and practices. However, this overview can only be general, as the specific impacts depend on the local context.

9.3.1 Broader Classes of Approaches

Resource-conserving agriculture and **sustainable intensification**[9] have many commonalities with the aim to make best use of natural resources and ecosystem services in a sustainable manner and to simultaneously promote social, environmental and health objectives and while increasing productivity (Pretty et al. 2006; Bennett and Franzel 2013). Bossio et al. (2010:5) consider a wide range of measures that belong to resource-conserving agriculture, such as eco-agriculture,

[9]For a discussion of the differences and commonalities between the concepts of sustainable intensification and ecological intensification see Tittonell (2014).

Table 9.1 Overview of identified approaches and agricultural techniques for an ecosystem-based approach to drought risk reduction

Agricultural practice	Multiple goals	Environmental benefits, Ecosystem Services	Socio-economic benefits	Scale	Relevance of locally adapted techniques using diverse knowledge sources	Drawbacks
Organic agriculture	Agro-ecosystem health and biodiversity conservation, sustainable and healthy livelihoods, food security, climate change adaptation (e.g., FAO/WHO 2006; Müller et al. 2013)	Water holding capacity, soil fertility, biodiversity all increased, reduced pest pressure, carbon sequestration (Müller 2009)	Net income increases, reduced health risks, reduced economic risks, improved food security, reduced migration (Panneerselvam et al. 2013)	Field → catchment	Use of locally available natural inputs, complementing organic agricultural practices with local knowledge (Barron 2006)	Labour and knowledge intense, availability and transport of organic matter, lower yields compared to intensive, conventional systems with inorganic fertilizer application, certification costs, risk of drop in demand (Müller et al. 2013; Panneerselvam et al. 2013)
Conservation Agriculture	Sustainable, resource-efficient agricultural production, environmental conservation, improved livelihoods, strengthening resilience and adaptation (Niang et al. 2014; FAO 2015d)	Fertility increase, water holding capacity improvement through build-up of soil organic matter, higher rainfall infiltration, soil moisture, a gradual increase of soil carbon, biodiversity increase, (Thierfelder	Increase economic gross margins, increased and stable crop yields (Thierfelder et al. 2013)	Field → catchment	Building on traditional technologies practiced by local farmers for example for intercropping agricultural production systems (Lahmar et al. 2012)	Low biomass productivity and multiple uses hence high opportunity costs of crop residues, labour intense during aggradative phase, and due to weeding, but later labour requirements decrease (Lahmar et al. 2012;

(continued)

Table 9.1 (continued)

Agricultural practice	Multiple goals	Environmental benefits, Ecosystem Services	Socio-economic benefits	Scale	Relevance of locally adapted techniques using diverse knowledge sources	Drawbacks
		et al. 2013), gradual soil quality improvement (Corbeels et al. 2014)				Corbeels et al. 2014), complex interactions between soil types, seasonal effects and tillage (Baudron et al. 2012)
Agro-forestry	Income security, food security, strengthening resilience and adaptation, environmental protection (Niang et al. 2014; van Noordwijk et al. 2014)	Microclimate improvement, soil protection, soil fertility increase, carbon storage increase, biodiversity increase, better water and nutrient cycling, ground water recharge, reduced run-off, erosion and flooding control (Bayala et al. 2014)	Availability of easily accessible forest products at critical times, diversity of products and improved diet (Bossio et al. 2010; Bayala et al. 2014)	Field → catchment	Farmer managed natural regeneration (Reij et al. 2009), role of local knowledge emphasized for successful agro-forestry (Chazdon 2008)	A dense tree canopy can also reduce crop yields, and increases diseases, competition between the plants for nutrients and water (Bayala et al. 2014)
Water harvesting	Drought mitigation, adaptation, food security, strengthening social and ecological resilience	Water productivity increase, reduced erosion, soil fertility increase, improved soil moisture, runoff and groundwater	Yield increase, reduced agricultural expansion, improved water availability, reduced flood risk	Field → Catchment	*Zaï* and half-moon techniques are build on traditional knowledge (Reij et al. 2009)	Ex-situ: evaporation and seepage losses, siltation, capital intensive, community institutions needed, knowledge

	(Biazin et al. 2012; Dile et al. 2013)	recharge, reduced risk of erosion (Yosef and Asmamaw 2015), increase in biodiversity, local groundwater recharge, land rehabilitation, reduced stream flow pollution, increased biodiversity and carbon sequestration	(Yosef and Asmamaw 2015)			on the downstream impacts (Lasage and Verburg 2015), risk of vector borne diseases (Yosef and Asmamaw 2015) In situ: water logging, labor intense, no protection against poor rainfall distribution, water logging, labor intense (Biazin et al. 2012)
Evergreen agriculture	Improve livelihoods, sustain resource base, sustainable food security, environmental resilience (Garrity et al. 2010)	Soil fertility increase, soil carbon increase, water infiltration and water holding capacity of soils increase (Garrity et al. 2010)	Yield increase, higher benefit to cost ratio (Ajayi et al. 2009), income diversification, increased food security, fodder production	Field → catchment	Farmer managed natural regeneration and further locally adapted strategies exist (Reij et al. 2009; Garrity et al. 2010)	Slow initial growth phase of fertilizer tree Faidherbia, knowledge intensive, initially very labor intensive (Garrity et al. 2010)
Ecological intensification	Making use of the regulating functions of nature at landscape level (Bommarco et al. 2013; Tittonell 2014)	Better provision of climate change related ecosystem services, such as carbon sequestration, energy use efficiency, soil water holding capacity, resilience to drought and excessive	Integrated pest and disease management, enhanced productivity (Ochola et al. 2013)	Landscape level	Techniques to increase soil organic matter content are an important part of many traditional farming systems, complemented with scientific research	Knowledge and labor intense (Ochola et al. 2013), an understanding of relations of land management and ecosystem services at different scales is needed, research/

(continued)

Table 9.1 (continued)

Agricultural practice	Multiple goals	Environmental benefits, Ecosystem Services	Socio-economic benefits	Scale	Relevance of locally adapted techniques using diverse knowledge sources	Drawbacks
		rainfall (Rossing et al. 2013), in field and off-field diversity (Crowder et al. 2010; Bommarco et al. 2013), soil fertility improvement and ecological adaptability (Ochola et al. 2013)				knowledge gaps (Bommarco et al. 2013), transition period until benefits occur (Tittonell 2014)

conservation agriculture, water harvesting, organic agriculture, integrated pest management and others. These approaches draw on the capabilities of smallholders to be innovative and manage and conserve land through participatory methods of decision-making, implementation and capacity building. Integrated pest and nutrient management, conservation tillage, agroforestry, cover crops, aquaculture, water harvesting and livestock integration are usually referred to as sustainable intensification approaches (Pretty et al. 2011). Pretty et al. (2011) compiled evidence from African farmers, applying a wide range of approaches for sustainable intensification and found evidence of reduced soil erosion; increased resilience to climate-related shocks such as droughts; increased soil carbon content; improved water productivity; reduced debt and production costs; livelihood diversification; and improved household-level food security and income. These approaches, therefore, meet many of the criteria as detailed in Box 9.1.

Sustainable land management (SLM) is "*land managed in such a way as to maintain or improve ecosystem services for human well-being, as negotiated by all stakeholders*" (Winslow et al. 2009:63). It includes other approaches such as soil and water conservation, natural resources management and integrated ecosystem management and aims to achieve productive and healthy ecosystems by integrating social, economic, physical and biological needs and values in a holistic manner (Liniger et al. 2011). Among others, Thomas (2008) emphasizes the role SLM could play in simultaneously addressing problems of land degradation, climate change adaptation and mitigation and biodiversity conservation. Liniger et al. (2011) stress the ability to prevent, mitigate and rehabilitate land degradation and address water scarcity, low soil fertility, lack of organic matter and reduced biodiversity. With the primary objectives of enhancing food production, addressing land degradation and providing sustainable and resilient livelihoods (UNCCD 2012b), these techniques are also associated with substantial economic, social and environmental co-benefits such as timber and fuel wood production, non-timber forest production, cultural preservation, biodiversity maintenance, recreation and tourism – all provided at usually low costs (Jones et al. 2012; Munang et al. 2014; Davies et al. 2015). UNCCD (2012d) report growing evidence that SLM can reduce poverty and lead to sustainable economic growth. All these benefits simultaneously strengthen the resilience of farmers and make their agricultural production less susceptible to droughts.

Climate smart agriculture is built on three main pillars, namely sustainably increasing agricultural productivity, increasing resilience to climate change and reducing greenhouse gases emissions (FAO 2010, 2013c). Context-specific and locally adapted techniques that address prevailing risks and livelihood situations are favored (Zougmoré et al. 2014). Climate-smart agriculture embraces all strategies that integrate land and water management, contribute to the build-up of soil organic matter and use varieties well adapted to changing climatic conditions. It therefore directly addresses the principles of EbA/Eco-DRR and supports CCA and DRR.

Ecological intensification is the use of all resources, such as land, water, biodiversity and nutrients, in an efficient, regenerative manner, while minimizing negative impacts. Therefore, it is considered by FAO as *"a knowledge-intensive* *process that requires optimal management of nature's ecological functions and biodiversity to improve agricultural system performance, efficiency and farmers' livelihoods*" (FAO 2015a:1). It is a context-specific, ecosystem-based, "*smart use of the natural functionalities of the ecosystem (support, regulation) to produce food, fiber, energy and ecological services in a sustainable way*" (Tittonell 2014:58), recognizing the role of local and indigenous knowledge. Ecological intensification fosters the management of regulating and supporting services, while enhancing the productivity of agricultural systems and reducing anthropogenic inputs (Bommarco et al. 2013). It includes approaches based on agro-ecology, organic agriculture, some diversified farming systems, nature mimicry, some forms of conservation agriculture, agro-forestry and evergreen agriculture (Tittonell 2014). Through the direct management of regulating services, entry points for drought mitigation are inherent characteristics of this approach.

Eco-agriculture is an approach operating at the landscape level with the goal of maintaining biodiversity and ecosystem services and of managing agricultural production in a sustainable way, in order to improve rural livelihoods. The approach stresses links between different ecosystems and ecosystem functions at the landscape level (Scherr and McNeely 2008; Bossio et al. 2010). It provides opportunities to include ecosystem services that contribute to drought risk mitigation and drought resilience in multifunctional landscape planning. Eco-agriculture aims to advance multiple goals in the same landscape and hence provides room for explicitly targeting drought risk reduction and adaptation objectives, in addition to other objectives.

9.3.2 More Specific Approaches and Agricultural Techniques

Organic agriculture "*is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, cultural, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system. (...)*" (FAO/WHO 2006:2).

Organic agriculture is often recognized as an approach to sustainable livelihoods in the context of sustainable development and vulnerability reduction (Milestad and Darnhofer 2003; Borron 2006; Bennett and Franzel 2013; Müller et al. 2013). Key strategies for organic agriculture are crop diversification and increasing soil organic matter. Crop diversification contributes to a more efficient use of nutrients and water, with multiple sowing dates for different crops, which could decrease the risk of crop failures due to dry spells and increase livelihood resilience to such threats by providing different crops at different points in time and fostering biodiversity.

Increasing soil organic matter enhances nutrient levels in the soil and thus maintains/increases soil productivity. Soil organic matter also improves the soil's water holding capacity so that available water in the plant root zone is increased (Reganold et al. 1987; Emerson 1995; Pimentel et al. 2005). Therefore, organic agriculture is less susceptible to dry spells (see e.g., Kloos and Renaud 2014 for a study in northern Benin) and other extreme weather conditions such as drought, flood and waterlogging, as well as reduced wind and water erosion (IPCC 2007). Increased soil fertility and soil moisture have been found to increase yield (in low yield environments) and net income increases were observed, together with additional benefits such as improved food security, investment in improved housing conditions, school attendance of children and reduced migration (Panneerselvam et al. 2013).

Water harvesting is the collection of runoff for productive purposes. Water harvesting techniques can be classified into macro-catchment systems, micro-catchment systems and in-situ systems (Dile et al. 2013).[10] Ex-situ water harvesting systems have been shown to mitigate intra-seasonal dry spells and increase water productivity, which leads to yield improvements (Mwenge Kahinda et al. 2007). In-situ techniques prevent soil erosion, increase deposition of nutrients and organic matter and thereby improve soil fertility. They increase the soil water content in the root zone and therefore help bridge dry spells. Water harvesting systems have been found to contribute to yield improvements and to sustain ecosystems in agricultural landscapes. Through these mechanisms, social and ecological resilience to natural hazards are strengthened, and climate change and food insecurity are addressed. (Agro-)ecosystems can be stabilized, while additional benefits to people are provided (Biazin et al. 2012; Dile et al. 2013).

Among water harvesting techniques, there are many, sometimes traditional practices, which can be considered as Eco-DRR/EbA according to the criteria in Box 9.1, and which are multi-functional.[11] *Zaï* and half-moon techniques[12] are examples of traditional practices whereby run-off water and organic matter are concentrated in small pits, thereby conserving water and soil (Barry et al. 2008). These traditional methods have been extensively promoted and were well adopted by farmers in Burkina Faso (Kaboré and Reij 2004; Reij et al. 2009). Planting pits concentrate water and nutrients directly where needed by the crops, restore soil fertility, increase water holding capacity and directly collect water. This helps crops to survive long dry spells or dry spells during critical stages of crop growth (Reij et al. 2009). Due to the application of organic matter concentrated in the planting pits, trees and shrubs also germinate and are often found to be protected by farmers

[10]Dile et al. (2013) provide an overview of different types of water harvesting systems (ex-situ and in-situ), their biophysical and ecological functions, mechanisms, social implications and drawbacks.

[11]There are many mixed approaches. Applying organic matter or fostering the growth of nitrogen fixing trees is simultaneously a measure of nutrient management or agro-forestry.

[12]Small pits are called "*Zaï*" or "*tassa*" and larger, half-moon shaped holes "Demi-lunes" (half-moons).

in order to establish agro-forestry systems using *Zaï* for reforestation (Reij et al. 2009). However, problems of waterlogging may occur in very wet years (Lee and Visscher 1990). As land preparation is carried out during the dry season, labor for other crops is available during the start of the rainy season.

Overall, *Zaï* has proven very beneficial for badly degraded areas, such as in the Central Plateau region of Burkina Faso, where between 200,000 and 300,000 ha of land have been rehabilitated using the technique alone or in combination with stone bunds and/or agroforestry systems (Reij et al. 2009). This has been shown to improve food security by reducing the number of months without food deficits, to enable vegetation regrowth with additional benefits and to reduce migration rates due to improved livelihoods. The example from Burkina Faso is referred to as a successful EbA (Reij et al. 2009; Munang et al. 2014). In addition, there are other water harvesting approaches that combine traditional knowledge with scientific knowledge:

- Soil and water conservation structures such as terracing systems in steep zones or stone lines are known throughout Africa. Contour stone/rock bunds or vegetative barriers slow down and filter run-off, which facilitates infiltration and the capture of sediments, thereby increasing soil water and reducing erosion. '*Fanya juu*' terraces common in East Africa are built together with a ditch, along the contour of a sloping terrain.[13]
- Rainwater harvesting and catching runoff in small dams or waterholes is practiced in wide areas, as well as specific small-scale irrigation systems such as "*Ndiva*" (Enfors and Gordon 2008). Among the different water harvesting techniques, traditional micro-catchment approaches have been shown to attract the greatest uptake in the Sahelian zone of West Africa (Barry et al. 2008).

Evergreen agriculture involves integrating trees into cropping systems (Garrity et al. 2010) and is a combination of conservation agriculture and agro-forestry (see below) practices within the same location. Through the inter-cropped trees, a green vegetation cover is maintained throughout the year. Nitrogen-fixing trees increase the nutrient supply and trees generate organic matter, with positive impacts on water infiltration and the water holding capacity of soils, thus supporting drought resistance.

Garrity et al. (2010) describe case studies from Zambia, Malawi, Niger and Burkina Faso that present a variety of locally adapted strategies combined under the umbrella of evergreen agriculture. Many of these approaches show a reduction of climatic risks under evergreen agriculture.

Conservation agriculture (CA) is based on three principles: minimal soil disturbance; permanent soil cover; and crop rotations, in order to achieve

[13]Stone lines on low slopes are mainly found in West Africa (Burkina Faso, Mali, Niger); Earth bunds/ridges mainly in East Africa (Ethiopia, Kenya) and Southern Africa (Malawi, Zambia, Zimbabwe, etc.); *Fanya juu* mainly in East Africa (Kenya; also Ethiopia, Tanzania, Uganda); vegetative strips throughout Africa especially in the more humid parts (Liniger et al. 2011).

sustainable and profitable agriculture and improved livelihoods (FAO 2015d). It is increasingly promoted as a measure to address land degradation, mitigate droughts and increase economic gross margins. The soil organic matter content is often low in SSA; hence, the permanent organic soil cover in CA benefits the water balance and biological activity and contributes to the in-situ build-up of soil organic matter in the soil. However, manure and other organic matter are often scarce in African subsistence agriculture as it is used for multiple purposes (e.g. for fodder, building activities etc.), and this can hinder the success of CA in SSA (Lahmar et al. 2012). CA can help to conserve soil moisture because soil is covered by crop residues, which makes it an effective technology for mitigating the negative effects of erratic rainfall or dry spells (Corbeels et al. 2014). The recent IPCC chapter of WG II on Africa recognizes with high confidence that conservation agriculture, including approaches such as agro-forestry and farmer-managed natural tree regeneration, conservation tillage, contouring, terracing and mulching, *"provides a viable means for strengthening resilience in agro-ecosystems and livelihoods that also advance adaptation goals"* (Niang et al. 2014:1203).[14]

Agro-forestry means that trees are managed together with crops and/or animal production systems in agricultural settings (FAO 2013a). In general, agro-forestry systems are classified into agrosilvicultural ("trees with crops"), silvopastoral ("Trees with livestock") and agrosilvopastoral ("Trees with both crops and livestock"). Agro-forestry enables farmers to better withstand drought and climate change, enhances biodiversity, reduces erosion and contributes to water and nutrient cycling (Bayala et al. 2014). Forest resources, such as non-timber forest products, can provide safety nets in case of shocks as they are available when other resources may be affected by droughts. Trees are recognized for the multifunctional value they provide (Bossio et al. 2010). Agro-forestry parklands are traditionally used among Sahelian farmers (Boffa 1999; Bayala et al. 2014). Additional provisioning services such as food, fuel, fodder, medicine, wood and building materials become available for farmers and the local population. Furthermore, regulating services, such as micro-climate regulation and ground water recharge, and supporting services, which are needed to maintain other services, are provided. In particular, soil carbon sequestration, nutrient cycling and reduced greenhouse gas emissions are supplied (Bayala et al. 2014), and these services are also recognized to contribute to soil fertility improvements and water conservation.

The loss of traditional agro-forestry systems could be addressed by assisted natural vegetation, so-called Farmer Managed Natural Regeneration techniques (FMNR), which have resulted in a significant increase of tree cover in the Zinder and Maradi regions in Niger, compared to a few decades before. Reij et al. (2009) found that these techniques have reduced the villages' risks of food shortages[15]

[14]For more details on drivers and constraints for adaption of conservation agriculture in SSA see Corbeels et al. (2014).

[15]Agroforestry in Western Kenya has increased food security during drought and flooding by 25 % due to increased income and improved livelihoods (Thorlakson and Neufeldt 2012).

caused by droughts or other factors. Trees reduce wind speed, evaporation and the need to re-sow (Larwanou et al. 2006), freeing labor for other activities (Garrity et al. 2010). Furthermore, reduced migration, lowered infant mortality and empowerment of women were observed in villages with FMNR (Reij et al. 2009).

Agro-forestry and reforestation have been promoted and used in many SSA countries as a way to mitigate climatic variability, deal with droughts and reduce desertification (Fisher et al. 2010). Restoring forests seems to be more successful when approaches include local knowledge of tree characteristics, use diverse species with particular economic or ecological benefits and integrate forest rehabilitation into general development strategies (Chazdon 2008). However, it is important to be aware of potential trade-offs. While in parkland environments, for instance, trees have been shown to yield multiple benefits in terms of microclimate and soil fertility improvements, some questions remain about their effects on crop production through competition for resources, depending on the crop-tree combinations (Bayala et al. 2014).

Crop-livestock integration is very common in rain-fed farming systems in SSA (Powell et al. 2004). In these mixed systems, productivity and management of croplands, rangelands and livestock are closely linked via nutrient cycling (e.g. grazing, fodder, manure), income (availability, investment and storage), and labor (e.g. animal power).

An integrated farming system[16] is based on a coordinated framework in which the waste or by-products of one component are used as an input for other components (IFAD 2010). Due to the cyclic nature of production, management decisions related to one component may affect the others. Approaches to maintain and enhance the productivity of mixed crop-livestock systems require a thorough understanding of the socio-economic and biophysical components and interactions (Powell et al. 2004). In terms of DRR and CCA, a balanced approach is needed that incorporates minimization of risks associated with rainfall variability and/or dry spells and droughts through e.g. improved water productivity (see e.g. Herrero et al. 2010; Amede et al. 2011 for more information). However, currently, there is still a gap in the literature on how best to use the interactions in mixed crop-livestock systems to buffer farmers against climate change and droughts (Thornton and Herrero 2015).

In order to be fully effective, these approaches and agricultural techniques, including strategies to improve water and land management, need to be linked to

[16]Diversified systems consist of components such as crops and livestock that coexist independently from each other. In this case, integrating crops and livestock serves primarily to minimize risk and not to recycle resources. In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of available resources (FAO 2001 as cited in IFAD 2010).

complementary approaches such as integrated plant nutrient management,[17] integrated pest management,[18] timing of activities and diversification, as well as integrating livestock management, post-harvest management and marketing and institutional aspects (Rockström 2003). Integrated approaches that combine well-adapted, diverse crops and crop varieties, agricultural management practices that conserve soil and water and increase the resilience of the agro-ecosystem to droughts, and institutional and policy options of drought risk management (e.g. forecasting and early warning systems, input/output market development and insurance systems) can strengthen the resilience of the social-ecological systems at multiple scales (Shiferaw et al. 2014).

9.4 Discussion

This overview of different agricultural approaches and techniques is not exhaustive,[19] but shows that there are multiple ways of managing agro-ecosystems in order to provide benefits which strengthen ecosystem functions (in particular the directly drought-related variables of water-holding capacity and infiltration rates, which are both linked in part to the organic carbon content of the soils) and increase the ecological buffer capacity. Soil protection and better water and nutrient cycling are additional aspects that reduce the susceptibility of the environmental system to drought, but also improve soil fertility, which has direct positive implications for the social system. Furthermore, a suitable micro-climate and the maintenance of diverse species, generating multifunctional agro-ecosystems, may increase the response diversity and hence the capacity of ecosystems to buffer against droughts (Liniger et al. 2011). Additionally, carbon sequestration is one environmental benefit that contributes to climate change mitigation goals. Table 9.1 summarizes some important socio-economic co-benefits that are linked to the approaches. These benefits, such as increases in income, improved food and water security, improved health and reduced economic risks, all contribute to poverty reduction and sustainable development goals linked to EbA/Eco-DRR approaches (as described in

[17]Integrated Plant Nutrient Management *"aims to optimize the condition of the soil, with regard to its physical, chemical, biological and hydrological properties, for the purpose of enhancing farm productivity, whilst minimizing land degradation*" (FAO 2015c).

[18]Integrated pest management is an ecosystem-based approach to crop production and protection that aims to ensure the growth of healthy crops with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (FAO 2015b). Using an ecosystem approach to control pests, a "*coordinated integration of multiple complementary methods to suppress pests in a safe, cost-effective, and environmentally friendly manner*" is needed (Parsa et al. 2014:3889). Prevention of pests is addressed through developing ecosystem resilience and diversity for pest, disease, and weed control. Pesticides are only used when other options are ineffective (Pretty et al. 2011).

[19]We did not include livestock-related agricultural practices, nor specific forestry management systems or fish production.

Sect. 9.2, Box 9.1). Overall, these strategies ensure the flow of a wider range of ecosystem services, even when faced with climatic shocks, such as droughts.

While many of the reviewed approaches have particular links to EbA and Eco-DRR, there are also potential pitfalls. Increasing agricultural productivity is still an important aspect of many of the described approaches. When applying these approaches in an Eco-DRR or EbA context, the focus shifts towards ensuring productivity in drought-prone years and under difficult rainfall conditions, rather than aiming to maximize yields during years where rainfall patterns correspond well to crop water needs (Davies et al. 2015).

It is important for risk management to differentiate between manageable droughts, where improved management and livelihood resilience can help mitigate impacts at the farm or watershed level, and unmanageable droughts where the preparedness and coping capacities at the small-scale farmers' level are overwhelmed and mechanisms outside the watershed are required (Rockström 2003). However, we found that this issue is not very much discussed in the reviewed approaches and techniques. The degree of risk reduction that can be provided by these approaches, for individual farmers but also at larger landscape scales, seems to be less well researched.

Many of the approaches can increase the capacity of an agro-ecosystem to maintain its functionality in case of droughts and dry spells, but often, information is missing about the duration of dry spells that a particular approach is able to tackle. This hinders, for instance, the useful combination of ecosystem-based approaches with other DRR or CCA strategies, such as structural measures or disaster preparedness, in order to more efficiently reduce risks.

For example, Barbier et al. (2009) show in a case study in Northern Burkina Faso that micro-level water harvesting techniques are beneficial, but have their limits and are insufficient in order to substantially reduce vulnerability and poverty. Garrity et al. (2010) observe that some quantified impacts, at least for the FMNR-approaches at larger scales, are available, which could provide useful information for disaster risk managers. Another example is a study by Ajayi et al. (2009), which quantifies the impact of evergreen agriculture on food security by estimating the number of additional food secure days in a household. It is one example of how to quantify drought risk reduction impacts that goes beyond improved yields. Such an estimate could then provide useful information for a comprehensive risk reduction strategy (see Garrity et al. 2010).

Increasingly, there is a call for multifunctionality at the landscape level, as such a perspective can help to meet multiple objectives of food production, biodiversity conservation, land rehabilitation and also drought mitigation (Minang et al. 2015). Many processes have impacts off-site that require management at a broader scale in a systemic manner. As different ecosystem services require management strategies at different temporal or spatial scales, a landscape perspective is needed to ensure that broader scale ecosystem services are not negatively affected. For example, pollination services or biological weed control (e.g. within IPM) are affected by farm-level activities, but are also strongly influenced by the spatial configuration and diversity of the surrounding landscape (Bommarco et al. 2013). While soil-related services may be best managed at the farm-scale, *Zaï* and half-moon techniques, for instance, can increase water level and tree cover if applied at the watershed scale (Bayala et al. 2014). Some of the existing approaches, such as ecological intensification, explicitly operate at the landscape level; other site-level or farm-level approaches could also be applied at a landscape level. In the case of rainwater harvesting approaches, Karpouzoglou and Barron (2014) argue that successful generalization of the adoption of such technologies requires an understanding of the processes in play at various spatial scales which influence adoption. This includes the shifting ideology associated with food production systems (from purely productivist systems to factoring in equity and sustainability concepts in food production), integrating agro-ecological approaches into agricultural research and development, as well as putting more emphasis on traditional and local knowledge.

EbA and Eco-DRR span different spatial scales, from the local/community level to the subnational, national and sometimes international level. Because they are multisectoral and multidisciplinary, EbA and Eco-DRR require communication and consensus-building among all stakeholders.[20] Stakeholder communication, negotiation and participation are integral parts of sustainable land management. As local conditions need to be considered in Eco-DRR/EbA, specific, well-adapted and negotiated approaches are required.

A suitable Eco-DRR or EbA approach for drought risk reduction would therefore consist of multiple complementary tools, for instance drawing from the various agro-ecological approaches as well as other approaches. But before replications of successful approaches can be considered at larger scales, scientific evidence of the effects of the approach on the environment and livelihoods is required, so that it can be adapted to a given site. Many of the approaches presented above are extremely knowledge intensive due to the complexity of ecological processes, particularly when operating at different spatial scales. Local knowledge and traditional techniques play a key role in many approaches described above. Some of the examples of water harvesting techniques or agro-forestry are traditional practices (e.g. *Zaï*, *Fanya juu*), which have been revived and further developed and are well supported through institutions and policies.

To plan EbA and Eco-DRR at the landscape level, easy access to information about the approaches is required (such as ecosystem services provision, but also including governance and institutional aspects). One useful development in that

[20]There are a few examples in the region of successful large scale implementation of ecosystem-based measures to reduce the impacts of climatic droughts. In terms of large scale implementation, the Great Green Wall (GGW) initiative, which is an African partnership to tackle desertification in the Sahel and Sahara, is perhaps the most contemporary one. This initiative encompasses 13 countries and addresses the desertification problem through a variety of interventions (i.e. not limited to planting a tree barrier). It also aims to support the efforts of local communities in the sustainable management of their resources. By doing so, the initiative contributes to climate change mitigation and adaptation and to the improvement of the livelihoods of the communities in the region (FAO 2013b).

direction is the World Overview of Conservation Approaches and Technologies (WOCAT) platform, which aims to unite the efforts in knowledge management and decision support for up-scaling SLM among all stakeholders, including national governmental and non-governmental institutions and international and regional organisations and programmes. It provides a wealth of knowledge on sustainable land management, including global online databases (WOCAT 2015). A systematic assessment based on the concept of ecosystem services, and including long term impacts, could be helpful in comparing and selecting between complementary approaches and tools for an Eco-DRR/EbA strategy. A continuous dialogue between scientists and local farmers is needed in order to generate knowledge and exchange experiences (Tittonell 2014).

Governance is an important aspect of Eco-DRR and EbA and is explicitly referred to in many of the above described approaches and techniques. Resource-conserving agriculture, for instance, emphasises the use of participatory processes for decision-making, implementation and capacity building. Governance aspects of Eco-DRR and EbA could not be tackled in depth in this review chapter. However, it is important to stress that many successful approaches are built on customary governance schemes. These approaches strengthen the role of local practices and existing resource-governing institutions. Particularly from an EbA perspective, the existing governance and institutional systems need to be capable of supporting flexible and adaptive management,[21] given the prevailing uncertainties, non-linear effects, cross-scale effects and thresholds of social-ecological systems under climate change. Such systems should incorporate mechanisms for experimentation, innovation and learning, and management approaches at all levels need to be kept flexible and adaptive (Liniger et al. 2011).

9.5 Conclusions and Outlook

There are multiple approaches that apply ecological principles to ensure agriculturally productive farms and landscapes and the continuous flow of ecosystem services, even when hazards such as droughts occur. As drought prevention and exposure reduction options are very limited in drylands, strengthening the resilience of agro-ecosystems and reducing their susceptibility to drought impacts are necessary, while enhancing their capacities to cope and recover.

The literature reviewed still focuses very much on provisioning services, in particular, yield potentials. Increasingly though, studies are including additional ecosystem services and, in particular, longer term impacts on livelihoods, food and water security or off-site effects. However, assessments that quantify a wide range

[21] Instead of aiming to minimize disturbances and uncertainties, adaptive management strives to strengthen resilience by providing space for experimentation, learning and understanding of ecological processes (Darnhofer et al. 2010).

of ecosystem services and how they are impacted by droughts or how they can help provide resilient livelihoods have not yet been comprehensively researched. The lack of coherence in the existing assessments makes it difficult to compare studies in terms of impacts. More systematical assessments would be important in order to be able to combine approaches and agricultural techniques for Eco-DRR/EbA in a complementary way.

While many studies highlighted some socio-economic benefits from the approaches that can contribute overall to drought risk reduction and resilience, more research is needed specifically from an Eco-DRR perspective. How much do these co-benefits support disaster risk reduction when hazards of different intensities strike?

Despite all the positive aspects of Eco-DRR and EbA, an honest discussion of what Eco-DRR/EbA can and cannot provide is important (see e.g., Cook et al. 2015 for a similar discussion on ecological intensification). While many of the described approaches are considered to be win-win situations (Liniger et al. 2011), this is not always the case, and some require trade-offs in terms of ecosystem service deliveries (e.g. among different provisioning services, vis a vis regulating services). Missing information on the limits of Eco-DRR and EbA poses a challenge to their effective integration into DRR and CCA planning. This chapter has shown that many of the existing drought risk reduction approaches are Eco-DRR/EbA in nature, but that they are not the sole answer to mitigate drought risks in SSA's drylands.

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