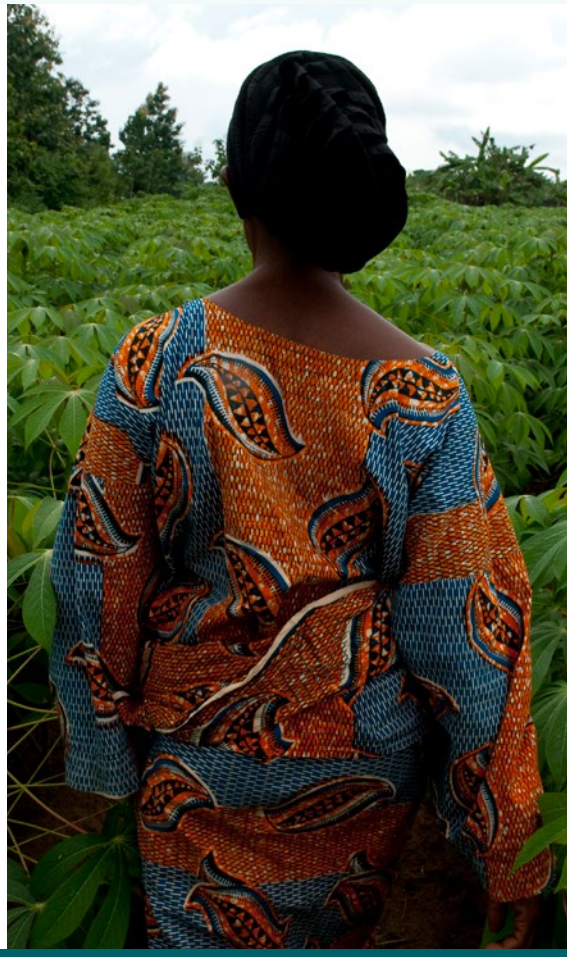
NOTE 3

Embedding Climate Resilience into Ecosystem and Water Projects

The Africa Climate Resilience Investment Facility (AFRI-RES) Learning Note

1. Why is embedding resilience into ecosystem and water sectors' infrastructure, planning, and policies important?

Ecosystems underpin sustainable development and human well-being in Sub-Saharan Africa. They deliver critical goods and services such as food and freshwater and offer stability and security to natural and social systems (World Bank 2020). The productive and protective aspects of ecosystem stability and water security are foundational for building adaptive capacity and resilience, which is increasingly being recognized through scaled-up financing for projects in these areas (World Bank 2023b). Ecosystem stability and water security in Sub-Saharan Africa can be enhanced through three key priority action areas: (a) enhance considerations of natural capital in macroeconomic and sectoral policy; (b) enhance management of landscapes, seascapes, and watersheds to increase resilience and enhance carbon sequestration; and (c) strengthen water security in the face of climate uncertainty through improved planning



The Africa Climate Resilience Investment Facility (AFRI-RES) is a partnership between the Africa Union, African Development Bank, the United Nations Economic Commission for Africa (UNECA), and the World Bank Group, established with support from the Nordic Development Fund (NDF). The partnership seeks to assist governments, planners, and private developers in integrating climate resilience in project planning and design, thereby attracting funding from both development and climate finance sources.

This note summarizes lessons and practices deployed in embedding climate resilience into the design of projects that received catalytic funds from AFRI-RES. It draws from application of the Resilience Booster Tool to specific projects, as relevant, Compendium Volume on Climate Resilient Investment in Sub-Saharan Africa (World Bank (2023a) and Guidance, Standards, and Good Practice Notes developed under the program.

African Union · United Nations Economic Commission for Africa · WORLD BANK GROUP · NDF Nordic Development Fund

and management (World Bank 2020). Ecosystem services form the foundation of livelihoods and wealth for a large portion of the African population, generating around one-third of economic growth in Sub-Saharan Africa (Lovei et al. 2017; Trisos et al. 2022). Over 62 percent of Africa's rural population depend on increasingly stressed ecosystems for their food, water, and energy needs (Africa Center 2022). Drylands make up around 43 percent of the continent's land surface and comprise 75 percent of the area used for agriculture, while providing homes for 50 percent of the Sub-Saharan African population (Lovei et al. 2017). The degradation of ecosystems, particularly drylands, jeopardizes people and their livelihoods by putting them in vulnerable ecological, economic, and socially precarious situations. Further, Africa's population is likely to double by 2050, which will put increased pressure on the region's ecosystems and biodiversity unless effectively managed through comprehensive policies and strategies (IPBES 2018). Environmental degradation of natural resources can strain economic progress and even cost some countries around 4 percent of their gross domestic product (GDP) a year (Aramide Awe 2012). High dependence on ecosystems points to the need to develop robust responses and management systems to mitigate the negative impacts of climate change on the population.

Sub-Saharan Africa faces escalating climate-related impacts that are exacerbating ecosystem vulnerability through land degradation. The primary causes include deforestation, poor management of cultivated land, and excessive use of agricultural technologies, all of which are exacerbated by drought (Lovei et al. 2017). Estimates suggest that up to 65 percent of productive land in Africa is degraded (Chomba et al. 2020). A key driver includes use that exceeds the carrying capacity of the land by an increasing number of people and livestock, which contributes to compromised water quality through soil erosion (Opperman et al. 2021). A study by the ELD Initiative and UNEP (2015) on 42 Sub-Saharan African countries[1] suggests that the economic impacts of soil erosion on cropland is detrimental and can result in a decline in GDP of up to 12 percent, signaling the importance of combating this trend.

Widespread deforestation is exacerbating climate change and reducing the adaptive capacity of local communities to respond to climate threats. It threatens livelihoods and food security and contributes to biodiversity loss. Africa is home to 17 percent of the world's forests (Berrahmouni and Mansourian 2021). The Congo Basin sequesters 4 percent of global carbon emissions annually and supports the livelihoods of 80 million people in the region (Africa Center 2022). However, Sub-Saharan Africa's forests are under threat, with the region losing 4.4. million hectares of forest annually between 2015 and 2020 (Berrahmouni and Mansourian 2021). Deforestation will continue to threaten the adaptive capacity of communities if robust forest management is not implemented.

Water scarcity and hydrological variability has led to more intense and frequent floods and droughts throughout Sub-Saharan Africa. These variable precipitation patterns have caused cascading impacts ranging from diminished hydroelectricity production to threatened food security (Kalantari et al. 2018; Trisos et al. 2022). Coastal areas are particularly vulnerable and are undergoing an alarming rate of environmental degradation. Flooding and coastal erosion in West Africa have damaged critical infrastructure assets and mangrove and marine habitats, and has caused loss of life (Croitoru, Miranda, and Sarraf 2019). On the other end of the spectrum, the Horn of Africa is entering its third year of drought after experiencing five failed rainy seasons since late 2020. This ongoing drought has displaced 1.4 million Somalis, led to considerable loss of agricultural crops, and killed 3.8

1 Angola, Arab Republic of Egypt, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Côte D'Ivoire, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Republic of Congo, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Togo, Tunisia, Uganda, Tanzania, Zambia, Zimbabwe.

million livestock (UN OCHA 2023). As a result of this ongoing drought, more than 6 million people are facing acute food shortages and malnutrition, compounded by a shortage of potable water and related disease outbreak (Palmer, Wainwright, and Dong 2023). The effects of climate change on ecosystems through floods and drought, in the backdrop of land degradation, are perpetuating vicious cycles that increase vulnerability of the most marginalized segments of the population.

Action Areas for Integrating Climate Resilience into Ecosystem and Water Sector Projects

Intervention Area	Purpose	Examples
Physical preparedness and protection	Withstand impacts of shocks and fluctuations to maintain characteristics and performance	Implement improved vegetation and soil cover (increasing plant density, cover cropping, earlier planting, relay planting, mixed or intercropping, contour planting, and mulching)
		Protect wetlands to provide ecosystem services such as flood protection, rehabilitation of gullies to reduce erosion, flood risk, and property damage
		Invest in hardware (water quality stations, automatic weather stations) for riverine flood risk management
		Develop infrastructure such as flood barriers, flood storage basins, gully erosion control structures, and rehabilitation of irrigation facilities
		Restore forested landscapes
Capacity Building	Gain or create knowledge, and build the skills, attitudes and competencies needed to innovate and adapt to change	Build institutional capacity to implement policies on sustainable land use practices and watershed management
		Develop adaptation options related to irrigation, drainage, and water management for agricultural producers
Adaptable decision-making	Flexibility in response to uncertainty	Install early drought systems to detect drought onset and assess response options

Source: Adapted from Ospina and Rigaud 2020.

Integration of climate resilience into the ecosystem and water sectors in Sub-Saharan Africa

Embedding climate resilience into ecosystem and water projects in Sub-Saharan Africa enhances the adaptive capacity of people and systems to better respond to escalating climate impacts. Table 1 summarizes ways to integrate climate resilience into ecosystem and water projects that focus on different aspects of resilience, from physical preparedness to institutional capacity building.

Proposed measures in ecosystem and water sectors projects to increase resilience

Sustainable land management strategies. Sustainable land management (SLM) is essential for enhancing ecosystem resilience through curbing rates of land degradation and improving livelihoods. According to the World Bank (2008, 5), SLM is "a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management to meet rising food and fiber demands while sustaining ecosystem services and livelihoods." SLM can support coordination between stakeholders; enhance resilience through implementing or scaling up environmental

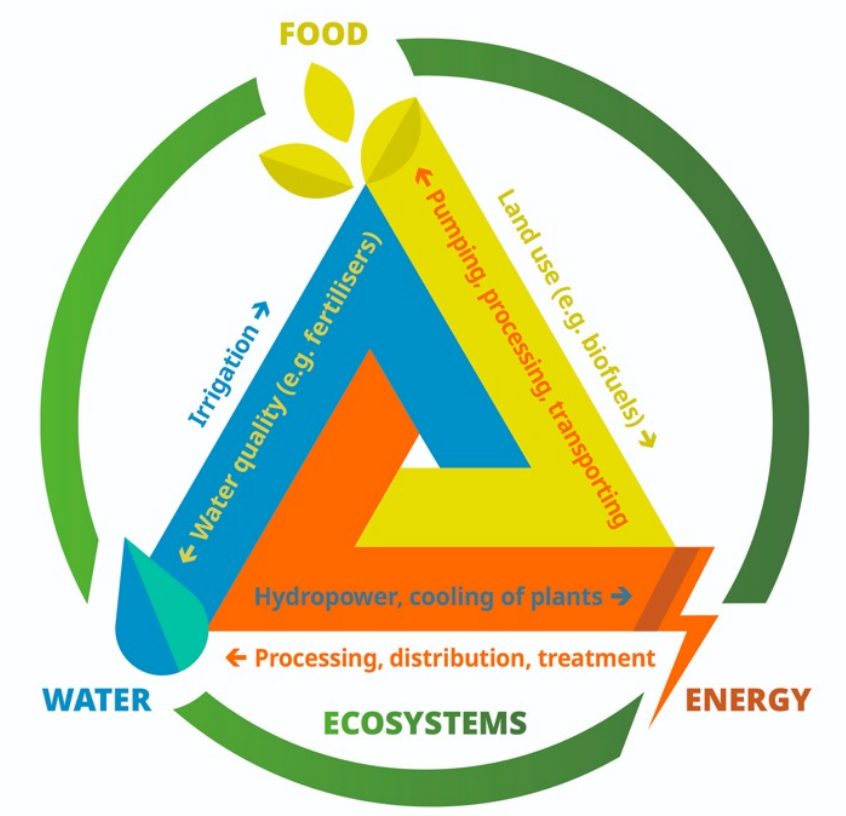
Figure 1. Elements that Support Sustainable Land Management.

Source: Adapted from World Bank 2021

safeguards and restoration efforts; and support the sustainable intensification of resource use (Cervigni and Morris 2016). Key activities include (a) preserving and enhancing the productive capabilities of cropland, forestland, and grazing land; (b) sustaining productive forest areas; and (c) maintaining the integrity of watersheds for water supply and hydropower (World Bank 2008). SLM approaches often focus on preventing soil erosion and improving biodiversity through vegetation management and sustainable irrigation systems (Sanz et al. 2017). SLM offers a holistic approach to preserving or restoring ecosystems in the near and long term by pursuing multiple avenues of intervention, including stakeholder engagement, establishing environmental baselines and economic incentives, boundary setting, and capacity building (figure 1). SLM can bolster the overall resilience of ecosystems, which can enhance the adaptative capacity of vulnerable communities.

Leveraging nature-based solutions and blue/green infrastructure for ecosystem resilience. Nature-based solutions (NBS) are central to climate change adaptation and building resilience in landscapes and communities. NBS protect, restore, or sustainably manage natural ecosystems while simultaneously providing biodiversity and livelihood benefits (World Bank 2022). NBS can include planting of mangroves to combat coastal flooding, implementing blue/green infrastructure in urban spaces to reduce urban heat island effects, planting trees to enhance carbon sequestration, and restoring native vegetation to minimize the impacts of soil erosion on watersheds that provide drinking water (Acreman et al. 2021; Seddon et al. 2020; Van Zaten et al. 2023). NBS are frequently viewed as potential cost-effective solutions to Sub-Saharan Africa's growing infrastructure needs. Compared to traditional gray infrastructure, NBS can maximize resilience to climate risks with limited resources that are up to 50 percent less

Figure 2. Interlinkages of the Water-Energy-Food Nexus as Underpinned by Ecosystems.



Source: GWP 2019

expensive than traditional infrastructure (Bassi et al. 2021; Oliver and Marsters 2022). Leveraging NBS can deliver ecological and social benefits by strengthening the adaptive capacity of systems to support ecosystem resilience.

Water-energy-food nexus. The water-energy-food (WEF) nexus offers a holistic and cross-sectoral approach to embedding resilience into strategies for managing the impacts of climate change. The WEF nexus stems from understanding that water, energy, ecosystems, and agriculture are strongly interlinked (figure 2), and the use of a WEF resource in one sector affects the availability of another resource in a neighboring sector (Mpandeli et al. 2018). If not coordinated, attempting to achieve resource security in one sector can threaten the security of other sectors (Adom, Simatele, and Reid 2022). The WEF nexus thereby allows policy makers to identify synergies and trade-offs that arise from managing these resources and offers pathways to approaching issues such as food security without compromising biodiversity and ecosystem services (De Laurentiis, Hunt, and Rogers 2016). For example, micro-irrigation and solar-powered irrigation pumps can limit trade-offs associated with increasing food production by preventing or mitigating emissions from the energy sources required to power the infrastructure (Mpandeli et al. 2018). Further, the WEF nexus can support sustainable land use and agricultural practices and prevent the degradation of ecosystems and their services, particularly when employed proactively. Proactive interventions, such as planned investments to enhance the adaptive capacity of agricultural systems through implementing new and efficient irrigation systems, can contribute to the long-term adaptation and resilience of systems (Mpandeli et al. 2018). Thus, integrated approaches to the WEF nexus can ensure sustainable access and availability of resources and enhance the resilience of communities and systems to climate shocks.

Case Studies from the AFRI-RES Supported Ecosystem and Water Sector Projects on Integrating Resilience into Designs

Four World Bank projects that focus on ecosystems and water received financing under the Africa Climate Resilience Investment Facility (AFRI-RES) fund. The project interventions showcase that climate-smart irrigation systems and sustainable land and water management systems offer integrated approaches to climate adaptation and mitigation that not only support agricultural productivity but also safeguard biodiversity, water resources, and ecological balance. These strategies and interventions will ultimately strengthen Sub-Saharan Africa's ecosystems and watersheds against climate change and create more resilient systems.

The Nigeria, Ghana, and Ethiopia projects applied the Resilience Booster tool in the project design stage to support the development of the resilience narrative in the project objectives and outcomes. The Resilience Booster is an interactive, step-by-step tool for development practitioners to embed climate resilience through a set of resilience attributes into project designs. It helps teams to think through, specify, and design project activities that build resilience by integrating resilience attributes. The results of the application of the Resilience Booster are detailed at the end of the project description if available.

Uganda Irrigation for Climate Resilience Project

Irrigation systems are being leveraged in Uganda to boost farmers' adaptive capacity to respond to Irrigation systems are being leveraged in Uganda to boost farmers' adaptive capacity to respond to increasingly unpredictable hydrometeorological trends and achieve national food security. The Uganda Irrigation for Climate Resilience Project (US$169.20 million) aims to provide farmers in the project areas with access to irrigation and other agricultural services, and to establish management arrangements for irrigation service delivery. To build climate resilience, there is an urgent need to create conditions for rapid scalability of irrigation systems that allow farmers to cope with climate variability, increase crop yield and intensification, and diversify toward higher-value crops. The project will construct new **irrigation networks using pipes, canals, and hydromechanical equipment**; support the **strengthening of management of existing irrigation schemes**; and **develop studies for future irrigation schemes**. Through implementing new irrigation and drainage systems, the project will **avert decreases in crop yield** that are forecasted as a result of changing precipitation patterns. The project estimates that 58,100 farmers will benefit from new or improved irrigation services and increase crop yields by two to five times the current rate.

Project interventions adopt an integrated WEF nexus approach to build the resilience of farmers, communities, and infrastructure. The new irrigation and drainage systems will **enhance farmers' resilience to water shortages and floods** while **bolstering farmers' resilience to future climate shocks and food insecurity from crop loss**. The project invests in activities that will increase farmers' access to and adoption of irrigation systems, which contribute to resilience through a WEF nexus approach. **Solar-powered irrigation pumps** will prevent emissions from the energy sources required to power the infrastructure needed for scaled-up agricultural production. **Access to reliable irrigation services** will allow farmers to sustain production over the wet season should rainfalls fail and increase intensification in the dry season. **Improved crop yields and increased diversification** and **intensification** will lead to **improved livelihoods and resilience to climatic events**, particularly with food security. The project will promote **SLM practices and integrated pest and disease management**. By focusing on the

land, water, food, and energy components of the WEF nexus, the project has embedded resilience into its components to ensure a holistic approach. Therefore, intervention in one project area will not undermine resilience in another sector, fostering a harmonized and climate resilient framework.

Nigeria Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) Project

Farmer-led irrigation development (FLID) holds great potential to sustainably increase agricultural productivity and enhance climate resilience in Nigeria. The Nigeria Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) Project (US$700 million) aims to increase the implementation of SLM practices in targeted watersheds in northern Nigeria and strengthen Nigeria's long-term enabling environment for integrated climate-resilient landscape management. A subcomponent of ACReSAL, funded by AFRI-RES, focuses on FLID, in which farmers take the lead in the establishment, improvement, or expansion of small-scale irrigated agriculture. Through FLID, farmers can grow crops year-round which, in turn, will **reduce the vulnerability of communities to food shortages and enhance their ability to cope with climate shocks**, thereby **bolstering the resilience of the farmers and their crops.** Further, **solar technologies** in the FLID systems have significant potential to **mitigate greenhouse gases** and allow Sub-Saharan Africa to leverage **clean and green development pathways**.

The proposed FLID will be more robust and resilient as a result of task team–led activities that informed the final FLID design. At the outset, there were insufficient data on areas where groundwater irrigation would be economically feasible in Nigeria and what sustainable financing options would be available for solar irrigation technologies. The task team identified activities to **catalyze farmer and private sector investments into irrigation**, which informed the FLID design. The task team led a series of **stakeholder workshops** to create awareness on the large potential for solar irrigation in northern Nigeria and to foster buy-in for FLID activities among key stakeholders, including government institutions, donor agencies, and the private sector. These workshops allowed the team to draw on their **experiences and knowledge** to ensure that the FLID establishes **multistakeholder platforms that facilitate partnerships among government and nongovernment actors**, including **irrigation technology** providers, smallholder farmers, academic institutions, and government institutions. Further, the task team laid the groundwork for diverse uptake of the irrigation systems by a wider group of farmers by establishing a **challenge fund to stimulate private sector innovation** to address barriers to farmer participation in FLID. The task team's analytical work focused on the economic feasibility of solar-based groundwater irrigation by assessing **biophysical conditions, cropping patterns, and whole-life financial cost**. These outcomes fed into the design of the FLID to make the proposed system more robust and resilient.

The FLID approach enhances resilience of its users by adopting a participatory micro-watershed planning framework that highlights **multistakeholder actions** and **collective decision-making** on **sustainable and equitable use of water resources**. FLID's three-pronged approach strengthens the **resilience of people, systems, and assets**. The first prong is a granular assessment of water resources and crop rotations. It enhances resilience of assets and infrastructure through strengthening the robustness of the irrigation system by determining context-specific limitations or opportunities for FLID's implementation. The second prong is adopting a **market-based approach** to stimulate the private sector. It enhances resilience of people through **inclusion** by allowing for the service to reach farmers in traditionally underserved areas of Nigeria. The third prong is strengthening the enabling environment to address barriers that limit farmers' access to solar irrigation technologies.

Applying the Resilience Booster tool, a focus on learning as a resilience attribute is linked to capacity building initiatives in market segmentation, agricultural extensions, water resource management, and social inclusion in irrigation, which can contribute to increasing **adaptive** capacity. There is emphasis on **rapidity** through interventions including mobilizing private sector investment for faster and easier access to FLID technologies and providing **results-based financing** to private companies to **improve their response time** to increased market demands for FLID.

Ghana Landscape Restoration and Small-Scale Mining Project

SLM can enhance resilience through reversing the land and forest degradation trend by harnessing sustainable forest and water resource management strategies. The Ghana Landscape Restoration and Small-Scale Mining Project (US$90.6 million) aims to strengthen integrated natural resource management and increase benefits to communities in targeted savannah and cocoa forest landscapes. The project focuses on strengthening the sustainable management of forest landscapes for biodiversity conservation and ecosystem services through bolstering institutional capacity for enhanced forest management, providing training and skills development to farmers on landscape management, and holding stakeholder consultations. The project encourages the establishment of greater tree cover and supports efforts to avoid forest degradation. It will incorporate NBS in targeted landscapes to mitigate negative environmental impacts around mining areas. Through sustainable crop and forest landscape management, the project will contribute to strengthening economic and adaptive resilience by bolstering the natural capital asset base of rural farmers, increasing the diversity of smallholder farming systems, promoting equity and inclusion of vulnerable and marginalized groups, and improving the availability of and smallholder access to climate information through knowledge exchanges.

Strategic shifts toward better-managed natural resources through an SLM approach will improve the resilience of livelihoods and assets by reducing the risks of climate shocks. The project will strengthen institutions for participatory landscape management by enhancing multipurpose land and water management models at the national level through remote sensing data and geological surveys. This will support the development of spatial planning tools for mapping and monitoring impacts and effective monitoring of sustainable cocoa production, thereby avoiding future land degradation. The project takes a holistic, basin-level planning approach to addresses issues of sustainable water planning, which will increase the resilience of ecosystems and watersheds by accounting for not only the environmental but also the socioeconomic components of SLM. By pursuing multiple avenues of SLM interventions, including stakeholder engagement via consultations, implementing NBS, and increasing economic benefits for farmers, SLM can bolster the resilience of the project.

A focus on robustness, redundancy, learning, and inclusion supports the project's overall resilience. Applying the Resilience Booster tool, the project supports the robustness of physical infrastructure through targeted investments in developing community micro-watershed infrastructure, which enhances the system's ability to withstand shocks. The project embeds redundancy by supplementing existing landscape services with landscape restoration, natural regeneration, and enrichment planting. Project components foster learning by providing skills development and training on forest and landscape management, which build competencies to innovate and adapt to change. The project focuses on inclusion by supporting women to take leadership roles. Working together, these four areas of intervention bolster the overall resilience of the project by applying a climate-informed lens to the project components and objective.

Ethiopia Resilient Landscapes and Livelihoods Project II (RLLP II)

Green infrastructure and sustainable land and water management practices in Ethiopia can support the development of resilient livelihoods. The Ethiopia Resilient Landscapes and Livelihoods Project II (US$178.24 million) aims to improve climate resilience, land productivity, and carbon storage, and increase access to diversified livelihood activities in selected rural watersheds. A key component focuses on increasing the adaptive capacity of the population to climate change by scaling up sustainable land and water management practices in watersheds, which will reduce soil erosion and enhance robustness of the system to respond to shocks. Interventions will include financing sustainable land and water management interventions on communal and individual lands, gully rehabilitation, supporting green corridors to link fragmented forests, and developing infrastructure such as water harvesting structures. Planned reforestation and afforestation of degraded forest and shrublands will enhance soil fertility. The project will adopt climate-smart agriculture practices to increase productivity and resilience of crops against drought through activities that support farm water and soil moisture management and integrated soil fertility and management. These sustainable land and water management strategies will support ecosystem resilience in the face of escalating climate impacts on landscapes, watersheds, and livelihoods by enhancing the adaptive capacity of the project components, thereby bolstering overall project resilience.

The Resilience Booster tool identified interventions designed to enhance the resilience of infrastructure and assets. Interventions to support the robustness of the project include soil and water conservation practices, afforestation, and reforestation. The project supports learning through building local capacity by training farmers on sustainable land practices. The development of watershed plans with multiple activities based on local needs supports flexibility and diversity, contributing to support the adaptive capacity of the system.

The project focuses on strengthening the **sustainable management of forest landscapes for biodiversity conservation and ecosystem services** through **bolstering institutional capacity** for **enhanced forest management, providing training and skills development to farmers on landscape management,** and **holding stakeholder consultations.** The project encourages the establishment of **greater tree cover** and supports efforts to **avoid forest degradation**. It will incorporate **NBS** in targeted landscapes to mitigate negative environmental impacts around mining areas. Through sustainable crop and forest landscape management, the project will contribute to strengthening **economic and adaptive resilience** by bolstering the natural capital asset base of rural farmers, increasing the **diversity** of smallholder farming systems, promoting **equity and inclusion** of vulnerable and marginalized groups, and improving the **availability of and smallholder access to climate information through knowledge exchanges.**

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