Adaptation for Smallholder Agriculture Programme

ASAP

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Investing in rural people

NATURE-BASED SOLUTIONS

ASAP TECHNICAL SERIES

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TABLE OF CONTENTS

Tables

Figures

ACRONYMS AND ABBREVIATIONS

AFOLU	agriculture, forestry and other land use
ASAP	Adaptation for Smallholder Agriculture Programme
ASAP+	Enhanced Adaptation for Smallholder Agriculture Programme
BIRDP	Butana Integrated Rural Development Project
COVID-19	coronavirus disease 2019
EbA	ecosystem-based adaptation
EC	European Commission
EM	effective micro-organisms
EX-ACT	Ex-Ante Carbon-balance Tool
FNML	Southern Laos Food and Nutrition Security and Market Linkages Programme
GHG	greenhouse gas
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
LMDP II	Livestock and Market Development Programme
LPDP	Livestock and Pasture Development Project
NbS	nature-based solutions
NDC	nationally determined contribution
Nema-Chosso	National Agricultural Land and Water Management Development Project
NGO	non-governmental organization
NICADAPTA	Adapting to Markets and Climate Change Project
NRGF	natural resources governance framework
NRM	natural resource management
PASIDP II	Participatory Small-scale Irrigation Development Programme phase II
ProDAF	Family Farming Development Programme
PUU	Pasture User Union
SAD	diversified agricultural systems
SAF	agroforestry systems

EXECUTIVE SUMMARY

The nature-based solutions (NbS) concept emerged during the United Nations Framework Convention on Climate Change fifteenth session of the Conference of the Parties (COP 15) in 2009. It was developed from the ecosystem-based adaptation concept, which integrates biodiversity and ecosystem services as part of an overall adaptation strategy, but shifts from focusing solely on nature (ecosystem-based adaptation) to focusing on people and nature (NbS). NbS put in perspective the fact that people can proactively protect, manage or restore natural ecosystems while significantly contributing to addressing six major societal challenges: climate change, food security, water security, human health, disaster risk, and social and economic development. The concept of NbS is increasingly being applied. At least 66 per cent of Paris Agreement signatories include some form of NbS-related interventions to help achieve their climate change mitigation and/or adaptation goals in their nationally determined contributions.

In 2020, the International Union for Conservation of Nature (IUCN) launched a Global Standard for Nature-based Solutions, defining NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". Some specific tools to operationalize the concept have been developed by, among others, the IUCN, the World Bank, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, the EU-funded ThinkNature project, the Nature-based Solutions Initiative at the University of Oxford, and Griscom et al. (2017). The last provides an exhaustive list of NbS in the agriculture, forestry and other land use sector.

This paper presents key results and lessons learned on NbS, mainly from IFAD's Adaptation for Smallholder Agriculture Programme (ASAP) portfolio, to inspire future programmes to reach greater scale in supporting inclusive rural transformation. The benefits of NbS have been analysed based on five themes and their associated desired benefits: climate change adaptation and disaster risk reduction; climate change mitigation potential; provision of non-carbon ecosystem services; food security and income generation; and social benefits. The study examined in-depth seven projects implemented in Ethiopia, The Gambia, Lao People's Democratic Republic, Nicaragua, Niger, Sudan and Tajikistan that illustrate the diversity of NbS implemented under ASAP, achieving different combinations of benefits. The main lessons learned can be summarized as follows:

- NbS can simultaneously meet several of the five above-mentioned criteria: climate change adaptation; climate change mitigation potential; provision of ecosystem services; food security; and social benefits. This shows the potential for multiple benefits of using NbS.
- NbS related to community-managed, climate-sensitive natural resources in drylands could be scaled up and applied to wider environmental projects, such as the Great Green Wall in the Sahara and the Sahel Boonxia Initiative, which IFAD is currently engaged in.
- The active involvement of local communities and authorities is critical to the success of NbS, and must be promoted through intensive mobilization and training.
- Labour-intensive NbS (e.g. digging trenches) often require significant external financial resources and specific approaches (e.g. cash-for-work schemes).

- NbS often promote a wide agrobiodiversity of local plants and trees, creating job opportunities for vulnerable women and young people. Diversification ensures that different households' needs are met (timber, firewood, food, income, biopesticide, etc.).
- NbS may in some cases require a long time to develop, as they can include multiple and complex activities, such as mobilizing communities or strengthening farmers' knowledge.

Stronger evidence of the results and impacts of NbS based on qualitative and quantitative data is required, to determine which benefits can be attributed specifically to NbS. Wider geographical coverage would also allow NbS to be tested in different contexts and facilitate their subsequent scaling up.

To ensure the stronger operationalization of NbS, more evidence is needed for NbS to be deployed at scale, to ensure the maximum benefits for society and nature. Here, IFAD has the opportunity to contribute through its future project designs, knowledge management, advocacy and policy engagement by:

(i) incorporating NbS in project designs, to address adaptation needs but also carbon sequestration and biodiversity restoration;
(ii) seeking opportunities to integrate NbS into rural development strategies, on the basis of experience gained through IFAD projects;
(iii) raising awareness and providing knowledge about NbS at local level;
(iv) ensuring that sufficient expertise is available to design, implement and monitor NbS – fostering a roster of non-governmental organizations (NGOs) and civil society organizations that are specialized in this topic is an interesting option;
(v) implementing NbS in different contexts and expanding their geographical coverage, through farmer-to-farmer exchanges and multi-country exchanges;
(vi) ensuring that NbS are systematically managed through strengthened local institutions, and that they are linked to local planning to adapt to climate change;
(vii) producing NbS-specific metrics to measure the social and environmental impacts of NbS.

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INTRODUCTION

Agriculture and livestock produce more than 25 per cent of total global greenhouse gas (GHG) emissions globally. GHG emissions, environmental degradation and biodiversity loss caused by the agriculture sector are mainly driven by land use change and unsustainable agricultural practices. These issues have profound social and environmental impacts, exacerbating existing humanitarian crises. The world's poorest people live in rural areas in the Global South and are hit earliest and hardest by these crises. The rural poor depend on natural resources for their livelihoods, including clean water, healthy soil, and a variety of genetic resources and ecological processes. The erosion of ecosystem services threatens the achievement of the Sustainable Development Goals. It is acknowledged, however, that healthier agricultural systems can be a solution in the fight against climate change if more sustainable practices are scaled up and integrated into policies, as reflected in numerous nationally determined contributions (NDCs). These solutions can also bring significant benefits in terms of food security, ecosystem services and social benefits. The nature-based solutions (NbS) approach uses tailored, innovative solutions based on sustainable natural resource management and conservation to address these interlinked societal and environmental challenges.

In 2020, the impact of the coronavirus disease 2019 (COVID-19) pandemic on people's lives around the world clearly highlighted that agriculture needs to be better aligned with ecosystems to strengthen poor farmers' resilience to shocks and longer-term disruption (such as climate change and biodiversity loss).

IFAD recognizes the potential of NbS to enhance climate change adaptation and mitigation, biodiversity and environmental health, and the resilience of ecosystem services and agriculture. In 2012, IFAD launched its Adaptation for Smallholder Agriculture Programme (ASAP) to make climate finance work for smallholder farmers, aiding those who contribute the least to climate change but who are most vulnerable to its impacts (BOX 1). Despite the reliance of the agricultural sector on a healthy environment, agricultural expansion and intensification are the lead drivers of biodiversity decline and contribute to GHG emissions and environmental degradation. Thus, the sector is critical to tackling environmental and social issues such as poverty, food insecurity and malnutrition. ASAP projects promote sustainable, biodiversity-sensitive agricultural practices and climate-smart adaptations to promote a healthy biosphere and provide long-term food security and nutrition to rural communities.

ASAP has played a major role in scaling up successful "multiple-benefit" approaches in IFAD's portfolio, which improve smallholder farmers' production while reducing and diversifying climate-related risks. In this study we discuss ASAP interventions in the NbS context. NbS are particularly relevant to ASAP because the concept reinforces that people are not only passive beneficiaries of ecosystem services and biodiversity, but they can also proactively protect, manage or restore natural ecosystems and the services they provide. This can significantly contribute to addressing climate change and other major societal challenges.

The NbS concept has powerful potential, but there is a lack of operational clarity and guidelines on how to plan, implement and assess NbS. This is an obstacle for broad-scale uptake and investment. In response to this, the International Union for Conservation of Nature (IUCN) recently published its Global Standard for Nature-based Solutions to help users design, implement and verify NbS actions. With better operational guidelines there is great potential to integrate NbS into the design of IFAD projects, especially in the current phase of ASAP, the Enhanced Adaptation for Smallholder Agriculture Programme (ASAP+). Here, we present the current state of NbS using case studies of projects from IFAD's ASAP (annex 2). These provide examples and evidence of the existing use and implementation of NbS in IFAD projects. We explore a wide range of uses and benefits of NbS that may help to build a strong case for investment in and use of NbS.

Box 1. The Adaptation for Smallholder Agriculture Programme (ASAP)

Smallholder farmers inhabit some of the most vulnerable landscapes on earth, such as hillsides, rangelands, semi-arid and arid lands, deltas and flood plains, and rely on climate-sensitive natural resources to make a living. They are on the front lines of climate change, facing significant risks from increasingly uncertain temperatures, erratic rainfall, pest infestations, rising sea levels, and extreme events such as floods, droughts, landslides, typhoons and heatwaves. Crop yields and food security are threatened in these unprecedented times.

ASAP is IFAD's flagship programme for channelling climate- and environment-related finance to smallholder farmers. It was launched by IFAD in 2012 to make climate and environmental finance work for smallholder farmers. This US$300 million multi-year, multi-donor financing window has provided a new source of cofinancing to scale up and integrate climate change adaptation across IFAD's portfolio. The programme benefits from the same rigorous monitoring and evaluation and quality control as IFAD's regular programme of loans and grants. The second phase of the programme was approved in 2017 and is being implemented in parallel to the first phase.

During 2020, in which 15 first-phase projects crossed their midpoint and 10 projects closed, IFAD commissioned a midterm review of the programme.

On the back of the successes and lessons learned from the first two phases of ASAP, ASAP+ was launched in 2021. ASAP+ is a 100 per cent climate financing mechanism and is believed to be the largest fund dedicated to channelling climate finance to small-scale producers to help them combat the climate change and social drivers of food insecurity. ASAP+ has a mobilization target of US$500 million to deliver on the programme's two focal outcomes, which will contribute to enhancing the climate resilience of 10 million vulnerable people.

Outcome 1: to increase the resilience of vulnerable communities, farmers, fishers and pastoralists – including women, youth, indigenous peoples and other marginalized groups – to the impacts of climate change on food security and nutrition.

Outcome 2: to reduce GHG emissions through win–win interventions that also yield significant food security benefits, particularly for vulnerable groups.

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2

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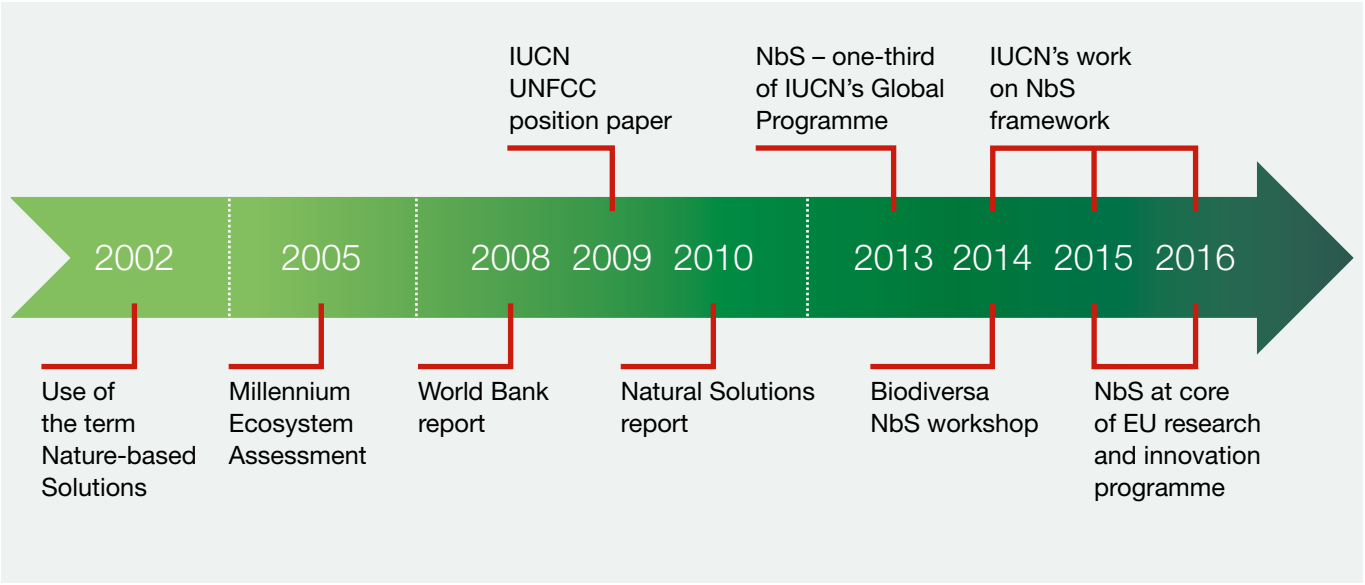
THE STATE OF NATURE-BASED SOLUTIONS

The concept and framework of NbS emerged during the United Nations Framework Convention on Climate Change (UNFCCC) fifteenth session of the Conference of the Parties (COP 15) in 2009 and is the result of an evolution of environmental concepts (FIGURE 1). The idea of environmental and ecosystem services was integrated into the scientific literature in the 1970s and, at the turn of the twenty-first century, the understanding of ecosystem management for adaptation to climate change emerged. The 2005 Millennium Ecosystem Assessment provided strong evidence linking global ecosystem degradation to a decline in human well-being, thereby promoting the conservation, restoration and sustainable management of ecosystems. Following this assessment, since 2008, the term ecosystem-based adaptation (EbA) has been used to define an approach that integrates biodiversity and ecosystem services as part of an overall adaptation strategy to help increase the resilience of people and ecosystems to climate change. With the concept of EbA as its foundation, NbS represent a paradigm shift from focusing solely on nature to focusing on people and nature (Mace, 2014) (box 2).

FIGURE 1. Evolution of the NbS Concept



Source: IUCN

There is limited research on the concept of NbS to date; however, it continues to be developed and diversified (Nessöver et al., 2017). Several definitions exist; for example, the IUCN defines NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN, 2020a), and the European Commission (EC) states that "Nature-based solutions aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions which are inspired by support by or copied from nature" (European Commission, 2015). Although these definitions are broadly similar, the EC has a larger focus on urban ecosystems owing to the high proportion of Europeans who live in cities. The IUCN definition is action-oriented and refers to three broad objectives:

- protection
- management
- restoration of ecosystems.

Box 2. The NbS concept

The concept of NbS is an umbrella concept that covers a range of EbAs that address societal challenges and simultaneously provide human well-being and biodiversity benefits, which in turn can improve the functioning of NbS and have impacts on human well-being (Naeem et al., 2016). The main types of EbA approaches included under NbS are categorized as:

- restorative (ecological restoration, forest landscape restoration, ecological engineering);
- issue-specific (ecosystem-based adaptation, ecosystem-based mitigation, ecosystem-based disaster risk reduction, climate adaptation;
- infrastructure-oriented (natural infrastructure, green infrastructure);
- management-focused (integrated coastal zone management, integrated water resources management); and
- protection-oriented (area-based conservation approaches, including protected area management and other effective area-based conservation measures).

They are summarized in the conceptual framework below (IUCN, 2020a).

Source: IUCN

IUCN identified six major societal challenges that NbS can address: **climate change, food security, water security, human health, disaster risk, and social and economic development**.

In an attempt to align the definitions of NbS and move towards a common understanding and consistent approach to the operationalization of the concept of NbS, IUCN (2020a) has developed **eight NbS criteria** for categorizing good NbS, building on several existing frameworks and a consultative process (box 3).

Some specific tools to operationalize the concept have been developed by, among others, IUCN, the World Bank (van Wesenbeeck et al., 2017), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the EU-funded ThinkNature project, the University of Oxford and Griscom et al. (2017). The last provides an exhaustive list of NbS in the agriculture, forestry and other land use (AFOLU) sector (TABLE 1).

Box 3. IUCN's core criteria for NbS

1. NbS effectively address societal challenges – this has been identified as a priority by those who are or will be directly affected by the challenges.
2. The design of NbS determined by their scale – understanding the interactions that affect attributes in and around the landscape/seascape, such as cultural values, laws, soils, forests and water, is important.
3. NbS result in a net gain of biodiversity and ecosystem integrity – by proactively enhancing the functionality and connectivity of the ecosystem they ensure their long-term resilience and durability.
4. NbS are economically viable – for the long-term success and sustainability of an NbS, the economic aspects must be considered; therefore, innovative and evidence-based tools for the valuation of nature need to be developed, as well as ideas of how NbS can contribute to markets and jobs.
5. NbS are based on inclusive, transparent and empowering governance processes – involving and responding to the concerns of a variety of stakeholders, especially rights holders, through mechanisms that actively engage and empower them, is important.
6. NbS balance trade-offs between achieving their primary goals and the continued provision of multiple benefits – which involves a credible assessment, full disclosure and agreement among the most affected stakeholders on how the trade-offs should be addressed.
7. NbS are managed adaptively, based on evidence – regular monitoring and evaluation, scientific understanding, and indigenous, traditional and local knowledge are the basis for enabling adaptive management through NbS.
8. NbS are sustainable and mainstreamed in an appropriate jurisdictional context – NbS interventions are designed and managed for long-term sustainability, to take account of, work with and align with sectoral, national and other policy frameworks.

TABLE 1. Summary of work to date on the concept of NbS by different entities/institutions

ENTITY	INITIATIVES, PUBLICATIONS, TOOLS AND OTHER NBS RESOURCES
IUCN	• Some specific tools have already been defined: – "Implementing nature-based flood protection: Principles and implementation guidance" by the World Bank (van Wesenbeeck et al., 2017); – "Ecological restoration for protected areas: Principles, guidelines and best practices" by IUCN (Keenleyside et al., 2012). • IUCN has also developed case studies to demonstrate the range of applications of NbS in different types of ecosystems and in different regions (Cohen-Shacham et al., 2016). • The IUCN Global Standard for Nature-based Solutions was launched in July 2020, providing a user-friendly framework for the verification, design and scaling up of NbS (IUCN, 2020a).
IPBES	• IPBES released a global assessment of biodiversity and ecosystem services (IPBES, 2019a, 2019b), which: – outlines the links between biodiversity and climate change (chapters 5 and 6); – discusses how to meet climate goals while maintaining nature and nature's contributions to people; and – provides references to pathways and options that help to reduce GHG emissions, such as options for dietary transitions and local food systems. • Chapter 6 briefly mentions **NbS as an approach for sustainable cities** (promoting green infrastructure such as green spaces, vegetation and tree cover in existing urban areas) as well as for sustainable freshwater management. • The IPBES has not yet conducted a detailed and systematic assessment of the synergies between climate change and biodiversity and has therefore, a fortiori, not compared or prioritized different NbS according to their estimated co-benefits.
Griscom et al. (2017)	• Griscom et al. (2017) conducted a comprehensive meta-analysis of the climate mitigation potential of "natural climate solutions" or "natural pathways" in the AFOLU sector. – The authors identified and quantified 20 conservation, restoration and improved land management actions across global forests, wetlands, grasslands and agricultural lands, which practitioners took to avoid GHG emissions and/or increase carbon storage. – These NbS are clustered in three groups: forests, agricultural lands and grasslands, and wetlands. **This is so far one of the only attempts to provide an exhaustive list of NbS in the AFOLU sector.** Example activities are proposed for each NbS in the article appendix, as reproduced in annex 1. • The article shows that **NbS can provide over one third of the cost-effective climate mitigation needed between now and 2030 to stabilize global warming to below 2°C**. • It also **identifies NbS co-benefits**, for biodiversity, water (both filtration and flood buffering), soil health/enrichment and air filtration. However, the article does not provide an in-depth analysis or evidence of the corresponding impacts of each NbS.
EU-funded ThinkNature project (https://www.think-nature.eu/)	• The project organized, developed and capitalized on a series of interventions: – Interviews, a summer school, a forum and a scenario game provided a range of perspectives on the future of NbS. – In 2019, ThinkNature developed an NbS handbook that provides general background knowledge; addresses issues relevant to different NbS stakeholder groups (research and innovation, business and policy sectors); and formulates key recommendations (Somarakis et al., 2019). The ThinkNature handbook specifically targets urban areas and development.

ENTITY	INITIATIVES, PUBLICATIONS, TOOLS AND OTHER NBS RESOURCES
University of Oxford – Nature-based Solutions Initiative (https://www.naturebasedsolutionsinitiative.org)	• The University of Oxford conducts an interdisciplinary programme of research, policy and education on NbS called the Nature-based Solutions Initiative. • This initiative brings together natural, physical and social scientists with economists and governance and financial experts. • Its mission is to enhance understanding of the potential of NbS to address global challenges and to increase their sustainable implementation worldwide. • The initiative has developed an "evidence platform" and a "policy platform" linking NbS to climate change adaptation. The evidence platform brings together 303 case studies, which are easily accessible using the following filters: – habitat type (referencing 26 of them, e.g. temperate forests, montane/alpine, created grassland, tropical and subtropical forests, coral reefs, tropical oceans); – climate change impact (referencing 22 of them, e.g. water availability, soil erosion, agricultural production, timber production, biomass cover, desertification, coastal inundation, wind damage, pests); – intervention type (created habitats, restoration, management, combination, protection, mixed created/non-created habitats); – effects of NbS on climate change impact (positive effects, unclear effects, negative effects, mixed effects, no effects, not addressed); – social outcomes (not reported, positive, mixed, unclear, no effect); – ecosystem outcomes (not reported, positive, mixed, unclear, no effect). • This platform makes it possible to share research publications about each practical case study that is referenced, and to have access to them in a clear and structured manner. It analyses impacts with regard to climate change, social issues and ecosystem outcomes, with the possibility of cross-analysing these impacts.
IUCN/Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) partnership and the EC	• The PANORAMA and OPPLA platforms were developed through the IUCN/GIZ partnership and by the EC, respectively. • Their objective is to enable a wide variety of institutions and individuals to share their experiences, challenges, lessons learned and success factors following the use of NbS. • Together, these platforms contain nearly 850 case studies on NbS across a wide range of issues and geographical areas. • OPPLA deals mostly with urban challenges, while PANORAMA deals with all environments. • Each platform groups the case studies by theme. For example, PANORAMA covers five themes: protected areas, business engagement, agriculture and biodiversity, EbA, and marine and coastal, with the possibility of selecting a region (five continents), an ecosystem (seven ecosystems proposed), a theme (17 themes, e.g. human development, gender-mainstreaming, ecosystem conservation), and a challenge (four challenges: climate change, and ecological, economic and social challenges).

3

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ANALYSIS: NATURE-BASED SOLUTIONS IN THE ADAPTATION FOR SMALLHOLDER AGRICULTURE PROGRAMME

3.1 Framework for analysis

For the purpose of this technical paper, we have developed our own analysis framework, which is broad enough to cover the different themes that NbS encompass but remains sufficiently simple and user-friendly for practitioners involved in ASAP and other rural development programmes.

This technical paper seeks to draw lessons from ASAP, whose projects target smallholder farmers and communities, and primarily address the impacts of climate change and biodiversity loss. We therefore look at NbS from the point of view of the benefits they can provide to smallholders and their communities, with a specific focus on biodiversity, climate change adaptation, resilience to climate shocks and other challenges smallholders may face.

We analysed the NbS used in seven ASAP projects, in Ethiopia, The Gambia, the Lao People's Democratic Republic, Nicaragua, Niger, Sudan and Tajikistan (annex 2), by type of benefit or impact, taking into account three broad categories of impacts: climate-related impacts, biodiversity and ecosystems impacts, and socio-economic impacts. We also made sure that there is coherence between the selected themes and benefits and the relevant Sustainable Development Goals, so that practitioners can easily understand our framework. The 20 NbS listed by Griscom et al. (2017) also helped in identifying and screening NbS activities in the sampled ASAP projects.

The analysis framework consists of five NbS thematic areas and their desired benefits, with a definition that specifically applies to ASAP and several examples of interventions targeted at achieving the desired benefits (TABLE 2). Further NbS interventions for climate action defined by Griscom et al. (2017) can be found in annex 1.

TABLE 3 presents the NbS used in the seven ASAP case studies and the primary and secondary benefits that the different NbS achieved according to the framework in TABLE 2. In the second part of this report, we present a synthesis of the case studies to illustrate how the NbS achieved the benefits that are listed in TABLE 3. The full case studies are presented in annex 2.

TABLE 2. Analysis framework for NbS in the ASAP case studies including five themes, each with associated benefits and examples of interventions

NbS THEMES	DESIRED BENEFITS	APPLICATION TO ASAP ACTIVITIES	EXAMPLES OF POTENTIAL NbS INTERVENTIONS
1. Climate change adaptation and disaster risk reduction	**1a** **Adaptation to the long-term trends and effects of climate change** (e.g. higher average temperatures, concentration of rainfall over a shorter period of time, changes in seasonal patterns)	NbS activities help smallholder farmers and communities cope with the long-term effects of climate change	**Crop diversification** and planting of local, climate-resilient varieties **Improved irrigation and water management**, such as drip irrigation or implementation of governance structures **Restoring local ecosystems** to improve availability of forage
	1b **Resilience to climate-related shocks**, that is extreme weather events (floods, drought, cyclones, etc.) and disease/pest proliferation	NbS activities increase the capacities of smallholder farmers and communities to withstand and recover from shocks linked to climate change	**Crop diversification** to reduce the risk of crop failure, and diversification of diets and livelihoods **Managing natural ecosystems** such as wetlands and mangroves to mitigate the severity and impacts of floods **Increasing agrobiodiversity** to mitigate the impacts of pests, through increased natural predators or pest deterrents and pest-resilient crop varieties
2. Climate change mitigation potential	**2a** **Reduction of GHG emissions**, including reduction in energy use and improved resource efficiency	NbS activities have the potential to avoid or reduce CO2 or other GHG emissions	Efficient natural resource management to reduce global emissions of GHGs **Biodigesters** used to produce cleaner, more efficient household fuel – limiting firewood extraction and household pollution **Sustainable rice-cropping** practices reduce methane emissions **Climate smart livestock feeding** reduces methane emissions
	2b **Improvement of carbon and other GHG pools**	NbS activities contribute to increasing biomass levels and have the potential to store carbon or other GHGs	**Forest conservation or restoration** to sequester more carbon **Avoiding wetland drainage**, preventing carbon release
3. Provision of ecosystem services	**3a** **Enhancement of biodiversity**, including agrobiodiversity and wild species	NbS activities contribute to the enhancement of biodiversity at the ecosystem, interspecific and intraspecific levels	**Crop diversification** promotes greater agrobiodiversity, including conservation of local varieties/breeds **Restoration of wild species and agroecosystems** helps to preserve ecosystem services such as pest control, pollination and water management
	3b **Preservation of freshwater resources** including irrigation potential	NbS activities ensure the availability of freshwater for human consumption and livestock and irrigation purposes	**Effective irrigation and management of water** sources helps to sustain water availability throughout the year for agricultural activities and other local uses by humans and wildlife
	3c **Soil conservation and improvement**	NbS activities preserve the health and productive potential of soils	**Rotational grazing** of livestock can mitigate soil erosion, improving soil fertility renewal, and soil water absorption and storage **Use of organic fertilizers** can boost yields without damaging soil and surrounding ecosystems
	3d **Reduction of air pollution**	NbS activities have positive effects on outdoor and indoor air quality	**Sustainable soil fertility and pest management practices**

4. Food security and income generation	**4a** **Improvement of food production**, including agricultural, livestock and fishery production	NbS activities contribute to the food and nutrition security of smallholder farmers and communities	**Shade trees** can help to improve crop yields and provide alternative nutritious food sources **Mangrove protection and restoration** improves fish breeding habitats and fish stocks **Grazing management** can boost animal health, growth and milk yields
	4b **Improvement of incomes** including farm and non-farm incomes	NbS activities provide sustainable incomes for smallholder farmers and communities, and in particular for youth and landless vulnerable groups	**Crop diversification** and creating sustainable environments for cash crops (such as planting of shade trees) can improve the yields and diversity of cash crops and forest products **Governance structures for natural resource management and ecosystem restoration and conservation** activities can create green jobs for local people
	4c **Local job creation including for unemployed people**	NbS activities create better/secure job opportunities for smallholder farmers and communities	**Governance structures for natural resource management and ecosystem restoration and conservation** activities can create green jobs for local people
5. Social benefits	**5a** **Improvement of land access**	NbS activities contribute to secure land rights and access for smallholder farmers and communities	**Natural resources governance frameworks** can help resolve conflicts over natural resources and promote participatory management and local access to natural resources
	5b **Capacity-building**	NbS activities contribute to building local capacities and knowledge	**Local or indigenous knowledge** can be a source of effective local solutions for climate adaptation **Conferring new agricultural practices** such as living fences, windbreaks and half-moons can help to restore the natural environment and protect crops from adverse climate change impacts **Training in new techniques** for management and efficient use of ecosystem services
	5c **Social cohesion and inclusion of marginalized groups**	The benefits of NbS activities are shared among the whole community, ensuring participation of and added value for every household and individual according to their needs and capacities	Marginalized groups such as women, youth and indigenous peoples often hold their own traditional knowledge or, in the case of youth, an aptitude for taking up and creating new practices, which can contribute to the resilience and prosperity of the wider community and empowerment of these groups Some NbS activities can be targeted at these groups and complement their particular attributes; others can be targeted at alleviating pressures on these groups. For example, better irrigation practices can alleviate some of the labour of water collection; and training in the use of organic fertilizers in home gardens managed by women can boost household income and nutrition NbS such as sponsored restoration projects also provide green jobs and income for marginalized groups
	5d **Gender equality and women's empowerment**	NbS activities contribute to gender balance and the empowerment of women	Women make up a large part of the agricultural workforce and hold their own traditional knowledge, often as stewards of local varieties of food crops that are not sold at market. Harnessing women's unique knowledge and improving their platforms in natural resource governance structures and decision-making can improve the stability and resilience of whole communities

TABLE 3. **Summary of the ASAP case studies including a categorization of the NbS used and the primary and secondary benefits achieved**

ASAP PROJECT/COUNTRY	NbS	NbS CATEGORY	MAIN SUB-CRITERIA ADDRESSED ≤ (AND SECONDARY ONES*)
Livestock and Pasture Development Project (LPDP) Tajikistan	Pasture rotation (or rotational grazing)	Grassland management/optimal grazing intensity	Enhancement of biodiversity **3a** /preservation of freshwater resources **3b** /soil conservation and improvement **3c** [Improvement of carbon and other GHG pools **2b** / improvement of food production **4a** /improvement of incomes **4b**]
Butana Integrated Rural Development Project (BIRDP) Sudan	Natural resources governance framework	Grassland and natural forest management	Improvement of land access **5a** /capacity-building **5b** /social cohesion and inclusion of marginalized groups **5c** /gender equality and women's empowerment **5d** [Improvement of carbon and other GHG pools **2b** / soil conservation and improvement **3c** /improvement of food production **4a**]
National Agricultural Land and Water Management Development Project (Nema-Chosso) The Gambia	Mangrove restoration	Coastal wetland restoration	Improvement of food production **4a** /improvement of incomes **4b** [Resilience to climate-related shocks **1b** / improvement of carbon and other GHG pools **2b** / enhancement of biodiversity **3a**]
Adapting to Markets and Climate Change Project (NICADAPTA) Nicaragua	Shade trees in diversified croplands	Trees in cropland	Adaptation to the long-term trends and effects of climate change **1a** /improvement of carbon and other GHG pools **2b** /enhancement of biodiversity **3a** [Soil conservation and improvement **3c** / improvement of food production **4a** /capacity-building **5b**]
Southern Laos Food and Nutrition Security and Market Linkages Programme (FNML) Lao People's Democratic Republic	Effective micro-organisms	Soil fertility and pest management	Improvement of food production **4a** /capacity-building **5b** [Improvement of incomes **4b**]
Participatory Small-scale Irrigation Development Programme phase II (PASIDP II) Ethiopia	Watershed management	Watershed management	Adaptation to the long-term trends and effects of climate change **1a** /resilience to climate-related shocks **1b** /preservation of freshwater resources **3b** / soil conservation and improvement **3c** /improvement of food production **4a** /capacity-building **5b** [Improvement of carbon and other GHG pools **2b** / enhancement of biodiversity **3a** /improvement of incomes **4b** /gender equality and women's empowerment **5d**]
Family Farming Development Programme (ProDAF) in the Maradi, Tahoua and Zinder regions Niger	Land restoration	Cropland and grassland restoration	Adaptation to the long-term trends and effects of climate change **1a** /resilience to climate-related shocks **1b** /improvement of carbon and other GHG pools **2b** /preservation of freshwater resources **3b** / soil conservation and improvement **3c** /improvement of food production **4a** /capacity-building **5b** [Enhancement of biodiversity **3a** /improvement of incomes **4b** /local job creation **4c** /gender equality and women's empowerment **5d**]

*Secondary benefits are those that are achieved through the NbS but to a lesser extent than the main benefits.

3.2 Synthesis of seven ASAP country-based case studies involving nature-based solutions

The seven ASAP case studies listed in TABLE 3 have been analysed in depth. They all illustrate various themes and benefits of the framework proposed. A full description of these case studies, with their strengths and weaknesses, is provided in annex 2. The link between the use of NbS and the fight against climate change is strong, and this is reflected in these ASAP case studies. The synthesis below summarizes the contributions to each facet of our typology.

ASAP nature-based solutions and adaptation to climate change

NbS interventions help households to cope better with climate change and variability. Most interventions used by IFAD in the ASAP involved landscape approaches that combined specific combinations of trees, planting techniques and land preparation to allow stakeholder/targeted households to cope better with climate-variability-related shocks. Several examples are listed below.

In Nicaragua, shade trees in coffee and cocoa groves help them to adapt to rising temperatures, which are expected to increase to a point that will impede the production of these key export crops by 2050. These shade trees contribute to creating cooler conditions at the plot level. In addition to the shade trees, leguminous plants (such as cowpea) provide permanent soil cover, which supplies the soil with nutrients and limits evaporation from the soil.

In Ethiopia, run-off due to precipitation peaks is becoming an increasing problem. To protect slopes from erosion and fields in the lowlands from siltation, a watershed approach has been promoted. Thanks to a range of techniques, watersheds have been protected and the project has been able to equip more rice fields with irrigation equipment, lowering the risk of flooding and infrastructure damage. These techniques are mainly based on the strategic use of vegetation, such as strips of grass on slopes, hedgerows composed of fast-growing species, and additional protection works to avoid the formation of gullies. Fifty thousand hectares of watershed are currently managed and protected through these techniques in the project area.

The same kind of landscape approach has been piloted and scaled up in Niger and Sudan, including various types of land restoration techniques and community natural resource management frameworks. These techniques encompass pasture restoration, forest management, cropland restoration through planting pits and improving traditional backyard gardens (*jubrakas*). Clear management rules are set up to enable biomass restoration in the long term. These frameworks have been selected as a model to scale up and are now promoted by national policy. The setting up of buffer zones (woodlots) and use of land restoration techniques that enhance water capture enable communities to be more resilient to the impacts of climate change in the medium term, thanks to improved yields and sustained sources of income.

In Niger, the project promoted an agroforestry technique – the assisted natural regeneration of useful trees in cropland. This was promoted at a significant scale and provides several functions with regard to climate change adaptation. The trees act as windbreaks against strong winds and sandstorms. They also contribute to lowering topsoil temperature at the plot level.

The last example of an NbS in this section is the promotion of mangrove restoration in The Gambia. Mangroves in The Gambia have long been considered as marginal zones and exploited for fuelwood. At the same time, mangroves are critical to protecting other parts of the landscape from current (storms and flooding) and future (rising sea level) impacts of climate change. The project empowers community groups to grow mangrove trees in nurseries and plant them to rehabilitate degraded mangroves. This contributes to setting up new buffer zones, protecting rice fields and providing gardens for horticulture. In total, 1,400 ha of mangrove have been rehabilitated in three regions of The Gambia next to the seashore and inland in high-tide-prone areas.

ASAP nature-based solutions and mitigation of climate change

NbS often have huge potential to sequester carbon. Several ASAP projects have invested in NbS that sequester carbon, in a wide range of landscapes and farming systems. The promotion of NbS such as pasture restoration, agroforestry systems, and mangrove management and restoration has achieved great results in this area. The potential for carbon storage over 20 years was assessed for these projects using the Food and Agriculture Organization's Ex-Ante Carbon-balance Tool, with most of the cases exhibiting a negative carbon balance (i.e. sequestration of carbon). In some cases, the contribution to the country's nationally determined contribution (NDC) target can be significant.

Mangrove restoration in The Gambia has the highest potential for carbon sequestration per hectare among the ASAP projects, with sequestration of 8.4 tons of CO_2 per hectare per year over 20 years. Mangrove restoration has also been promoted through an ASAP project in Djibouti.

Significant carbon storage in the soil has been achieved over huge areas in Kyrgyzstan, Niger, Sudan and Tajikistan through pasture restoration (TABLE 4). The amount of carbon stored per hectare is small, but the overall result is impressive owing to the number of hectares restored and can contribute a significant share to the countries' NDCs. The Butana Integrated Rural Development Project in Sudan restored more than 100,000 ha of pastoral land with a combination of grass and tree species.

In Niger, assisted natural regeneration of useful trees in cropland also provided a significant carbon sink. Local farmers have now implemented this technique on more than 120,000 ha of cereal fields, with tree densities of around 50 trees per hectare.

In Nicaragua, shade trees and permanent soil cover improve the level of carbon sequestered per hectare by setting up a multi-storey agroforestry system. The level of carbon in the soil is also significantly improved.

TABLE 4. Summary of the carbon sequestration potential of four of the projects analysed

PROJECT NAME/COUNTRY	CO_2E SEQUESTERED OVER 20 YEARS (TONS)	CO_2E SEQUESTERED PER HECTARE PER YEAR (TONS)	NDC TARGET IN TERMS OF TONS OF CO_2E
Livestock and Market Development Programme (LMDP II) Kyrgyzstan	2 259 000	0.5	74 000 000 (scenario 1, by 2030)
Adapting to Markets and Climate Change Project (NICADAPTA) Nicaragua	924 000	2.7	11 000 000 (for the land-use sector)
Family Farming Development Programme (ProDAF) Niger	5 263 000	1.2	33 000 000 (by 2030)
Butana Integrated Rural Development Project (BIRDP) Sudan	4 787 000	2.3	35 000 000 (across all forestry activities including restoration of degraded land, by 2030)

Notes: There are no data for the Tajikistan case study; however, LMDP II in Kyrgyzstan is a very similar pasture restoration project for which data have been provided. CO_2e, carbon dioxide equivalent.

ASAP nature-based solutions and ecosystem services

NbS can contribute to increasing agrobiodiversity and soil health and reducing pollution.

This is illustrated by the list of ASAP projects promoting sustainable management of biomass at the landscape level and the use of organic inputs at the farm level. Agrobiodiversity in particular is at the heart of pasture restoration and forest management.

Projects in Niger, Sudan and Tajikistan used a range of native trees and grasses to restore pastoral land. Biomass protection, either through rotational grazing in Tajikistan or through scheduled plot protection in Niger, leads to increased biodiversity in terms of species already present in the area simply by allowing for natural regeneration.

An increase in biodiversity can also be seen as a result of mangrove restoration in The Gambia. The restoration has improved the diversity and populations of local fauna that mangroves host, most notably of the many aquatic species that contribute to healthy diets and incomes, such as oysters, crabs and fish.

Soil health is closely interlinked with the level of organic carbon in the soil, as presented in the previous section. The technique used in the Lao People's Democratic Republic to improve soil fertility, using a compost soup containing bacteria acting as activators, is also very useful for stimulating the development of colonies of beneficial organisms already present in the soil. This agroecological technique contributed to revitalizing soils and improving crop production. In Niger, assisted natural regeneration contributed to the spreading of fertilizer trees such as *Faidherbia albida*, which capture nitrogen from the atmosphere and make it available in the soil.

NbS can also play a role in reducing the external input of chemicals used in agriculture. In Niger, some of the trees protected through assisted natural regeneration techniques act as insect repellents (*Piliostigma reticulatum*). Farmer field schools have promoted the use of biopesticides from neem tree leaves (*Azadirachta indica*) in three regions of southern Niger.

ASAP nature-based solutions and food security

NbS can also help to increase food security through land restoration, by introducing new species in farming systems and by protecting specific forests such as mangroves. This increases incomes through the marketing of agricultural surpluses and the creation of new micro-businesses and green jobs.

Cropland restoration led to significant cereal yield increases in Niger, from 400 kg to 800 kg of millet or sorghum per hectare. The use of bacteria as activators helped to more than double vegetable yields in the Lao People's Democratic Republic; however, so far this has been piloted only in small garden areas in this country.

The introduction of fruit trees in coffee and cocoa groves in Nicaragua also contributed to a more diversified diet, with vitamin-rich fruits (lemons and oranges) accessible to smallholder families. The introduction of plantain trees in these groves as intermittent shade trees is also improving food security.

In The Gambia, mangrove restoration is critical for small fish nurseries and the development of oyster colonies. These sources of seafood contribute to diet diversification in communities where rice is the basis of the diet.

Regarding incomes, improvements have been noticed in Niger and Tajikistan thanks to land restoration. A direct way of improving incomes is the delivery of small cash amounts for land restoration works. In Niger, women-led households are targeted for these activities, and they have been able to invest in small livestock thanks to this additional source of income. Goats purchased provide milk for the household, improving the nutrition of children. In Tajikistan, pasture restoration has improved the milk productivity of cattle, leading to better nutrition at the household level, and surplus milk and butter can be sold to generate additional income. Again in Niger, some native trees (*Balanites aegyptiaca*, *Acacia* spp.) planted in pastoral land provide raw materials such as gum and oil, which are valued for their use in making products such as soap. The implementation of NbS can also provide opportunities to create new green jobs

in communities. An interesting example is the creation of tree nurseries in Niger, managed by groups of women. This is a steady source of income, as they can work with the ASAP project or with other partners such as NGOs. Pasture restoration can also lead to the creation of temporary jobs as guardians; guardians ensure that cattle do not invade restored areas during the first three years after restoration, which is critical to protecting biomass regeneration.

ASAP nature-based solutions and social benefits

Promoting NbS is associated with the building of various social benefits. Their promotion requires setting up specific management frameworks and building specific skills in communities. This is needed for NbS promoted either at the landscape level or at the farm level. The analysis of these case studies provides evidence that, through specific targeting, fostering natural resource management committees and investing in extension systems are the main activities leading to gender empowerment, capacity-building of vulnerable groups such as women and young people, and customary rights protection in a range of ASAP projects.

In Niger and Sudan, women participate significantly in local processes and community groups aimed at setting up clear rules for natural resource management, notably in cases of climate-sensitive resources such as dry forests and pastures. This represents a significant step in these countries, where there are strongly embedded gender inequalities. In The Gambia, groups of women are instrumental in mangrove restoration, and they participate in local decision-making on climate change-related investments.

Promoting NbS also requires the implementation of capacity-building activities. Knowledge on the various benefits of NbS is provided through farmer field schools, for example in Niger and The Gambia, or through farmer-to-farmer extension systems.

Sometimes, NbS can act as vectors to facilitate and protect customary rights, such as land passage and pasture for nomadic groups. In Niger, efforts have been made to restore biomass in areas that have been invaded by non-edible grass species.

4

DISCUSSION AND RECOMMENDATIONS

4.1 Main lessons learned from ASAP case studies

The case studies analysed illustrate the diversity of the NbS that can be implemented in rural areas with smallholder farmers. The NbS presented in this paper are targeted towards different habitats and social contexts (cropland, grassland, forest and wetland) and have various goals (conservation, restoration and/or sustainable management). Moreover, each of them **simultaneously addresses several of the five NbS thematic areas** (climate change adaptation and disaster risk reduction; climate change mitigation potential; provision of ecosystem services; food security; and social benefits), showing the potential for multiple benefits of using NbS, which are described in section 3.

NbS implemented through ASAP projects most often **involve communities as well as authorities** (at local, regional and/or national levels), from the design to the implementation phases. Their active involvement is critical for the success of the NbS and should be promoted through intensive mobilization and training. When implemented adequately, this participatory approach directly tackles the need to consider site-specific natural and cultural contexts that include traditional, local and scientific knowledge. This ensures proper ownership of the NbS and builds the capacities and awareness of stakeholders by bridging the gap between modern scientific knowledge and traditional knowledge. Across the seven case studies, the strong involvement of communities and/or authorities is promising for the sustainability of the NbS. Sonneveld et al. (2018) found that most failures in NbS interventions could be attributed to top-down, non-participatory approaches and a lack of understanding of ecosystem functions.

NbS activities that are labour-intensive in their implementation or maintenance (e.g. digging trenches) often require **significant external financial resources**. This involves specific approaches that need to be planned at the project design level (e.g. cash-for-work schemes) and long-term financial planning to ensure the sustainability of NbS (e.g. through social safety net programmes).

When planting trees and grasses for landscape restoration, a **wide diversity of local species** is commonly proposed to avoid damaging local ecosystems (Seddon et al., 2020). To meet the different needs of the population (timber, firewood, food, incomes, etc.), it is important to provide rural households with plants that have different purposes (e.g. forest trees together with fruit trees and trees with medicinal properties) and that preserve soil and groundwater resources. These plants and trees are usually cultivated in **nurseries** that are specifically developed for the project and that ensure the availability of seedlings. Nurseries also provide job opportunities, which can be targeted at marginalized groups such as vulnerable women and young people. Taking care of the young plants to ensure sustainable tree growth is labour-intensive during the first three years. All these processes contribute to greater agrobiodiversity.

As shown in the Sudan example, NbS may in some cases **require time** to be fully deployed, as they include multiple and complex activities. A long timeline is necessary in the development of solutions such as designing new regulations and policies, mobilizing communities or strengthening farmer knowledge.

Among the case studies, some NbS were implemented with a relatively narrow **geographical focus**. Wider geographical coverage would allow NbS to be tested in different contexts and facilitate subsequent scaling up. Kumar et al. (2020) proposed the idea of open-air laboratories to provide benchmarks and field measurements and enable testing of NbS, to provide data and evidence on costs and effectiveness for scaling up of small-scale projects. Farmer-to-farmer exchanges are also very useful, as long as they are organized in areas with similar agroecological patterns and challenges.

4.2 Way ahead: towards the stronger operationalization of nature-based solutions

This review of selected ASAP projects confirms the potential for NbS to produce multiple benefits for small-scale farmers, agricultural systems and wider society. In many cases it takes time to reap these benefits, as biological processes take time and transitions to NbS often have initial up-front costs and perceived risks and uncertainties. This must be taken into consideration when promoting and planning NbS. To overcome some of the factors that can hamper the adoption of NbS in agriculture, new policies, payment methods and types of business cases could be developed (Sonneveld, 2018; Iseman and Miralles-Wilhelm, 2021). ASAP's blended finance model is a good example of innovative financing, providing grants to pilot innovations such as novel NbS, which de-risks their piloting and provides evidence of their success to encourage stakeholders to consider further investment.

While the ASAP case studies provide useful lessons, more evidence is needed for decision makers and donors to ensure that NbS move beyond site-based examples and pilot projects to be deployed at scale to secure maximum benefits for society and nature. Based on an extensive review of current NbS literature, Iseman and Miralles-Wilhelm (2021) conclude that there is increasing evidence on the triple benefits of NbS in agricultural production and resilience, in mitigating climate change, and in enhancing nature and biodiversity. They also point out that there are emerging examples around the world of farmers adopting nature-based practices, although data on the financial implications on a global scale are scarce at present. To enable the effective transfer of NbS approaches from pilots to larger scale projects and to make the concept useful in planning and implementing societal responses to important challenges, the global standard developed by IUCN (2020a) is useful and will help to generate a common understanding of and consensus on what is a "good" NbS. This is an exploratory standard that provides the tools to continue building the case for NbS. Greater evidence of successful upscaling and the multiple benefits of NbS will be required, as scaled-up NbS will need to account for changing environmental and social nuances when expanding into new areas.

The IUCN Global Standard for Nature-based Solutions currently provides the following guidance on the operationalization of NbS: (i) design new NbS; (ii) scale up pilots by identifying gaps; and (iii) verify past projects and future proposals (IUCN, 2020b). However, experience from ASAP highlights the importance of testing NbS prior to scaling up to ensure the quality and credibility of the solutions. The more comparable data there are for both failed pilots and successful NbS, the better conclusions and recommendations can be made about the sustainability and economic viability of NbS in agriculture.

The United Nations Decade on Ecosystem Restoration may contribute to boosting the global profile of NbS. It is crucial to get the messaging and implementation of NbS right, and to fully understand the values but also the nuances and limitations of the diversity of NbS and NbS contexts that exist (Seddon et al., 2019a; Seddon et al., 2019b; Seddon et al., 2020).

Several other initiatives, platforms and handbooks are also being developed to gather and share lessons on NbS implementation. They can support practitioners to build on previous experiences.

4.3 Lessons learned for future project design

1. Incorporate NbS into project design as part of integrated farming and landscape management approaches to build the long-term development and resilience of livelihoods for small-scale farmers and their communities. From inclusion in design, NbS should be tested and then scaled up if successful; many cultural and environmental nuances may limit some NbS from being directly transferrable. The inclusion of NbS at the design stage can contribute to the narrative on the expected contribution of a project to climate change adaptation, carbon sequestration and improvements in local agrobiodiversity.

2. Seek opportunities to integrate NbS into rural development strategies at national and regional institutional levels to expand their reach. This can be achieved by sharing IFAD projects' experiences after solutions have been scaled up, such as in the case of the natural resource governance framework in Sudan.

3. Raise awareness and knowledge of NbS and their potential to contribute to more sustainable food systems, to store carbon, and to improve resilience capacities and the nutrition of rural vulnerable households among field staff, implementing partners and targeted communities. This paper is a first step in this direction and the IUCN global standard is an example of a useful tool for guiding the work and developing specific training sessions. It is critical to invest in the training of local actors in this regard.

4. Ensure that sufficient expertise is available to design, implement and monitor NbS – it is important to have the proper technical expertise to ensure that NbS are correctly settled and to avoid improper application. Project teams must work with experienced practitioners and expertise in NGOs, academies and research institutions. IFAD projects can contribute to fostering rosters of local NGOs and civil society organizations focusing on NbS.

5. Implement NbS in different contexts and expand their geographical coverage – by implementing NbS, monitoring results and contributing to the systematic building of the evidence base in different farming system and territorial contexts, successful NbS can be scaled up and shared between farmers and communities facing similar challenges. Farmer-to-farmer extension systems and south–south exchanges are good tools for achieving this goal and can be included in new projects.

6. Ensure that NbS are systematically managed through strengthened local institutions – NbS should be implemented through a community-based and participative approach including local governments. This will contribute to the inclusion of NbS in local planning, for example to finance green infrastructure in communities to adapt to climate change.

7. Produce NbS-specific metrics to measure the social and environmental impacts of NbS – during the course of a project, the production of data is essential to providing strong evidence of NbS-specific results and impacts as part of integrated farming system and landscape management approaches. The data should contribute to enhancing understanding of how the implementation of NbS can strengthen resilience to climate change while creating carbon sinks to mitigate its acceleration. To produce these data, the metrics required to measure the social and environmental benefits of NbS must be identified during project design and used throughout a project. Projects must ensure that these monitoring and evaluation solutions are documented and shared through dedicated communities of practice.

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ANNEXES

Annex 1. Activities associated with 20 nature-based climate solutions

NbS	EXAMPLE ACTIVITIES
FORESTS	
Avoided forest conversion	Establishing protected areas and improving enforcement; improved citing of non-forest land use; forest certification; improved land tenure; commitments for zero deforestation; sustainable intensification of subsistence agriculture; avoiding loss of high-carbon forests; reduced consumption of land-extensive food types (e.g. beef).
Reforestation	Conversion from non-forest to forest in areas ecologically appropriate for tree growth through agricultural certification programmes and impact mitigation frameworks that prioritize restoration; regulations that advance minimum forest cover requirements; integration of trees into grazing lands (i.e. silvo-pastoral systems).
Natural forest management	Extension of logging rotations; reduced-impact logging practices that avoid damage to non-commercial trees; voluntary certification programmes; regulatory requirements that limit impacts from logging; improved land tenure.
Improved plantations	Extension of logging rotation lengths to achieve maximum yield while increasing average landscape carbon stocks; certification systems; multi-species plantation systems.
Fire management	Advance prescribed fires to reduce the likelihood of more intense wildfires in fire-adapted forests; advance fire control practices in tropical moist forests such as fire breaks between pastures and forest edges; regulations and certification programmes that promote improved fire management; improved forest management practices that reduce accumulation of debris from tree felling or destruction and improve resilience to natural disturbance.
Avoided fuelwood harvest	Reduce fuelwood harvest levels by adopting improved-efficiency cook stoves or stoves that use alternative fuel (e.g. solar, methane from agricultural waste).
AGRICULTURE AND GRASSLANDS	
Avoided grassland conversion	Establishing protected areas and improving enforcement to prevent conversion of grasslands to tilled croplands; improved land tenure; intensification of existing croplands.
Biochar	Extension programmes to build capacity in biochar management; improved land tenure; certification systems; incentive programmes.
Cropland nutrient management	Certification programmes that seek to maintain water quality by reducing excessive fertilizer; water quality/pollution mitigation; credit trading programmes; removal of regulations creating perverse incentives to apply excessive levels of fertilizer; improved manure management.
Conservation agriculture	Cultivation of additional cover crops in fallow periods; shift to reduced-tillage or zero-tillage systems and other conservation agriculture practices may enhance soil carbon benefits of cover crops.

NbS	EXAMPLE ACTIVITIES
Trees in cropland	Regulations and certification programmes that promote integration of trees into agricultural lands; agroforestry certification systems; increasing the quantity of trees in croplands by introducing windbreaks (also called shelterbelts), through alley cropping and farmer-managed natural regeneration.
Grazing – animal management	Adopting animal management practices that result in improved health, reduced mortality, improved genetics and live weight gain.
Grazing – optimal intensity	Maintaining forage consumption rates that enable maximum forage production; certification programmes.
Grazing – legumes in pastures	Sowing legumes in existing planted pastures.
Grazing – improved feed	Inclusion of cereal grains in feed to improve feed quality and reduce methane emissions.
Improved rice cultivation	Adopting water management techniques such as alternate wetting and drying and midseason drainage; residue incorporation; fertilizer management.
WETLANDS	
Avoided coastal wetland impacts	Establishing protected areas and improving enforcement; improved land tenure; no-net-loss mitigation regulations; avoiding the harvest of mangroves for charcoal; avoiding consumption of food products with acute impacts on coastal wetlands (e.g. mangroves replacing shrimp farms).
Avoided peatland impacts	Establishing protected areas and improving enforcement; improved land tenure; no-net-loss mitigation regulations; re-siting of oil palm plantation permits to non-peat locations.
Coastal wetland restoration	Re-wetting and replanting with native saltwater wetland species; wetland mitigation programmes.
Peatland restoration	Re-wetting and replanting with native freshwater wetland species; wetland mitigation programmes.

NbS, nature-based solution.

Source: Griscom et al., 2017

Annex 2. Case studies

Case study 1: Tajikistan – restoring pasture ecosystems through rotational grazing

NATURE-BASED SOLUTION PROFILE

PROJECT AREA

PROJECT: Livestock and Pasture Development Project, second phase (LPDP II).

DESCRIPTION: Pasture rotation (or rotational grazing) was developed for LPDP in Tajikistan. This NbS is about changing the way animals are grazed, exercising control over where and when livestock can occupy portions of the rangeland landscape, thereby allowing natural ecological processes to favour higher rainfall use efficiency, more plant growth and greater diversity of species in the vegetation (this case study is based on Norton, 2020).

NbS TYPE: Grassland management/optimal grazing intensity.

SPECIFIC NbS BENEFITS: Enhancement of biodiversity; preservation of freshwater; soil conservation and improvement.

OTHER BENEFITS: Improvement of carbon and other GHG pools; improvement of food production; improvement of incomes.

DURATION: 2015-2021.

TOTAL PROJECT COST: US$24.19 million.

FINANCING: Government of Tajikistan; IFAD; Adaptation for Smallholder Agriculture Programme (ASAP) Trust Fund; Debt Sustainability Framework; beneficiaries.

TARGET GROUP: 38,000 smallholder livestock households in 180 communities in five districts in the Khatlon region.

Background and development challenge

In Tajikistan, pastures underpin the resilience of communities. In the project area, more than 80 per cent of household's own livestock; the average household herd comprises four to five sheep and goats, often a cow and sometimes a donkey. Communal herds of livestock owned by many households are managed as one herd. Poor households usually have additional income from remittances from men working in Russia, or from small village enterprises.

Overgrazing and pasture degradation, linked to a growing population of livestock and unregulated pasture use, is a major problem throughout

Central Asia, especially near villages. Lower livestock production on degraded pastures affects the livelihood of many thousands of livestock-dependent households. The problem is livestock distribution rather than overloading; hence, the focus is on improving the planning of the management of pasture.

The extent of landscape and gully erosion is immense in Tajikistan, occurring on at least 80 per cent of the pasturelands and being particularly intense near villages at lower elevations. The silt soils prevalent in the Khatlon region have a very poor physical structure and are particularly susceptible to erosion and landslides. Poorly managed livestock grazing is the principal driver of erosion. The greatest climate change threat to Tajik pastures is the occurrence of severe storms causing accelerated soil erosion.

Description of nature-based solution

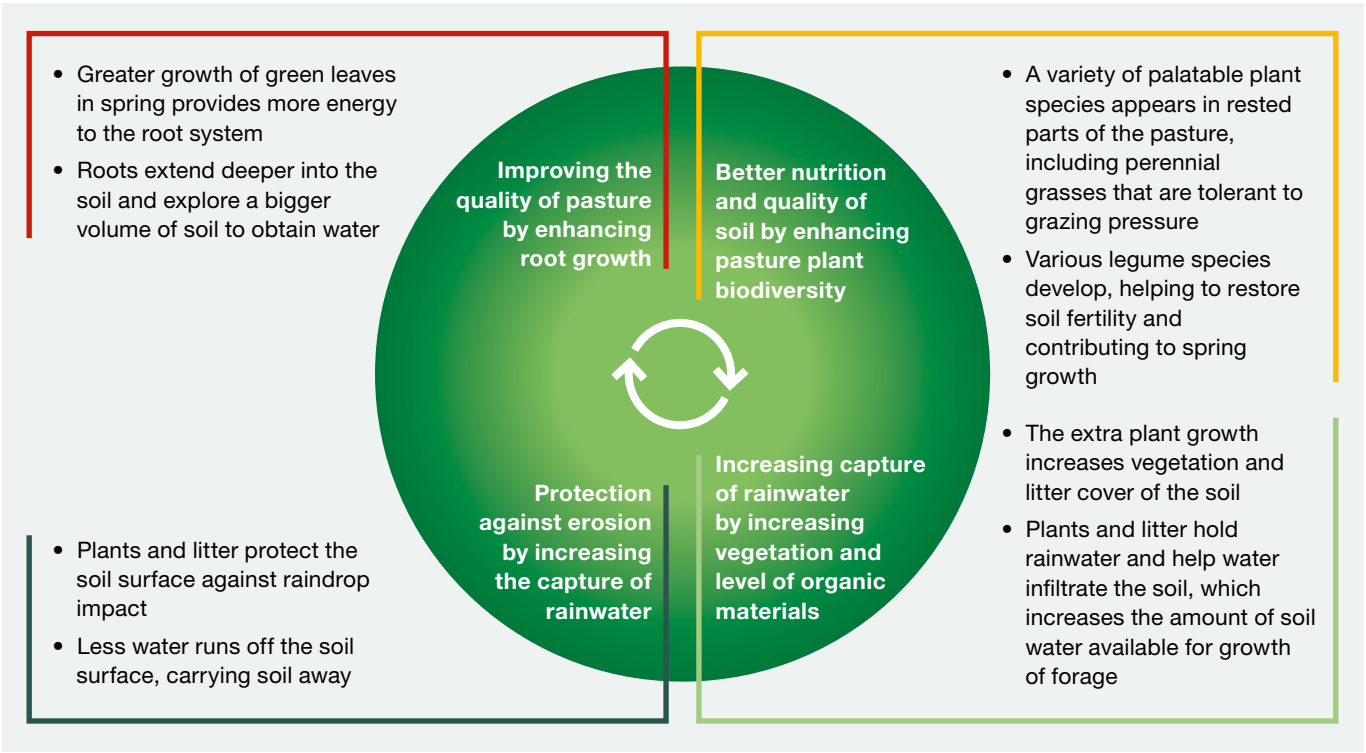
Pasture rotation maximizes pasture growth without reducing the number of animals. Carrying capacity is likely to increase when pastures are used more efficiently and trends of destructive grazing are reversed.

Rotational grazing restricts livestock access to small portions of pasture, which are grazed by the herd for short periods. After a short grazing period, the herd moves to another small grazing unit. The first grazing unit is allowed to recover and grow freely for the remainder of the season (FIGURE 2). There is no requirement to introduce plant species or irrigation water. This lapse of time gives a diversity of plants with seeds in the soil a chance to grow, resulting in more diverse vegetation and better soil integrity. It may also reduce the emergence of invasive plant species (e.g. *Caragana*) and protect endemic species.

In Tajikistan, the principal management unit is the Pasture User Union (PUU), whose main responsibilities are to collect fees, receive support from donors and the government, purchase equipment, manage infrastructure, supervise pasture management, and ultimately determine the locations and sizes of grazing units, composition of communal herds and timing of grazing periods each year. The PUU board appoints a grazing supervisor to oversee the implementation of the grazing plan.

PUU leaders were trained by the LPDP rangeland specialist in the principles and practice of rotational

FIGURE 2. Rationale for rotational grazing



grazing in each district. Training included internal study tours that involved high-performing PUUs sharing their experiences with struggling PUUs, and a Pasture Rotation Bulletin was designed to explain the principles involved to project staff and communities. Pasture rotation performance is monitored by the PUU using indicators such as pasture production in demonstration plots, the condition of grazed pastures, and livestock milk yield and live weight. Each village community is also required to establish a 1 ha fenced demonstration plot, protected from livestock and used for monitoring plant production, to track changes in vegetation composition and to test palatable forage species and shade trees.

Key results and impacts

Benefits of rotation reported by PUUs included (i) more forage on the pastures, of better quality (more diversity, more legumes, less unpalatable species); (ii) bigger, heavier, fatter livestock; (iii) a higher milk yield, often more than is needed for household consumption, with the surplus processed into milk products for sale; and (iv) more livestock in village herds.

More than 80,000 ha of pastureland (about 60 per cent of the total area of pasture available in the target districts, and 86 per cent of the total area covered by pasture in the 203 target villages) were improved in terms of productivity as a result of implementing rotational grazing. A survey conducted in 36 PUUs concluded that pasture productivity had increased by 8 per cent for the total biomass and by 19 per cent for the eatable biomass. This indicates a qualitative improvement of pasture, which should be confirmed in the longer term.

The increase in available forage led to an increase in livestock production and improved health. These benefits particularly helped women from poor households, who could sell or barter milk produced beyond the household's immediate needs. Numbers of livestock in household herds increased, allowing higher income from market sales.

In ecological terms, more cover of vegetation and litter reduced the threat of soil erosion. Pasture rotation is the primary mechanism for combating the adverse effects of climate change, and it has a broad application over entire landscapes.

According to an Ex-Ante Carbon-balance Tool (EX-ACT) analysis conducted on 10 IFAD investments supported by ASAP, a very similar project in Kyrgyzstan produced the second highest overall project mitigation benefits (0.5 tons of CO_2 equivalent per hectare per year), most of which is attributed to controlled grazing and winter and spring pasture improvement.

Limitations

With regard to environmental impacts, it takes a long time for the effects of pasture rotation to be seen. Future projects should include a more focused assessment of benefits (e.g. assessment of the nutritive value of pasture, remote sensing analysis of pasture for all PUUs, repeated botanical surveys to assess the impact on the floristic composition of pasture). Monitoring pasture production in demonstration plots presents a number of biases: it is unlikely that the specific conditions of demonstration plots (fencing, fertilizer use, full deferred grazing) can be scaled up.

The rest period in pasture rotation is likely to heal erosion gullies. However, data demonstrating this are not available.

Winter fodder remains a major limitation to livestock production in the Khatlon region, a situation that is exacerbated when the winter season extends for longer than usual.

Lessons learned

Five key components have been identified to achieve the best results from pasture rotation: (i) delay spring grazing until the temperature is higher, allowing grazed plants to recover and decreasing the risk of erosion, as, in a continental climate with winter–spring rains, pastures are vulnerable to trampling damage during early spring when temperatures are still low, plant recovery from grazing is slow and the ground is wet; (ii) allow grazing on each portion of the pasture for no more than 1 week; (iii) allow grazing on each portion of the pasture only once per year; (iv) from year to year, change the date at which a portion of pasture is subjected to grazing, so that an individual part of the pasture is never grazed at the same time in consecutive years; and (v) completely rest the worst-degraded areas for an entire year. To achieve components (ii) and (iii),

it may be necessary to adjust the size of grazed portions to prevent the need to regraze them. This will likely result in the concentration of livestock in small areas of pasture. However if the grazing period is short and the area will not be grazed again in the same year, ecological damage from short-term heavy grazing is unlikely to occur.

The success and long-term sustainability of a rotational grazing regime on extensive communal rangeland depends on a legal framework that grants authority to villages to manage the land, land tenure arrangements that provide security of communal ownership of rangeland and an effective management structure with accountability to the village households. When viewed in the context of reducing livestock productivity loss and household poverty, waterpoint development in grazed summer pastures that lack available drinking water is important.

A sound rotational grazing plan can be disrupted if livestock move onto spring pastures too early in the season. Yet the pressure to take animals out of the barn at the end of winter and put them on rangeland is strong. This problem can be addressed by ensuring that there is an abundance of stored hay and fodder to last through winter into the early spring. A key feature of LPDP was to supply PUUs with agricultural equipment, seed and fertilizer to facilitate the production of fodder crops.

Case study 2: Sudan – linking a rights-based approach to sustainable management of natural resources

NATURE-BASED SOLUTION PROFILE

PROJECT: Butana Integrated Rural Development Project (BIRDP).

DESCRIPTION: The natural resources governance framework (NRGF) implemented through the project is geared towards better management and shared use of natural resources in the target areas, including farmlands, rangelands and water.
The NRGF's objectives are to (i) establish a coherent and cost-effective governance framework that ensures regulated access to land and water resources of the Butana; and (ii) help communities to sustainably manage natural resources and reduce conflicts among end users (settled farmers and transhumant pastoralists) in Butana.

NbS TYPE: Grassland and natural forest management.

SPECIFIC NbS BENEFITS: Improvement of land access; capacity-building; social cohesion

and inclusion of marginalized groups; gender equality and women's empowerment.
OTHER BENEFITS: Improvement of carbon and other GHG pools; soil conservation improvement; improvement of food production.
DURATION: 2006-2019.
TOTAL PROJECT COST: US$46.69 million.

FINANCING: Government of Sudan; IFAD (including ASAP); Government of Italy; beneficiaries.
TARGET GROUP: 90,000 households in 540 communities in 10 localities in the five states of Khartoum, Gedaref, River Nile, Gezira and Kassala.

Background and development challenge

The Butana region of Sudan, has a typical Sahelian environment, characterized by low, erratic and spatially variable rainfall. Periodic droughts lasting two to three years are not uncommon. Butana has a population of about 800,000 people, most of whom live in settled communities. Livelihood systems combine crop-farming and livestock-raising. Butana is also used for wet season grazing by semi-nomads and transhumant herders. Poor communities rely on agropastoral and pastoral modes of production, with limited access to irrigation schemes or mechanized farms; lack of a permanent water source; an absence of social services; average to severe deterioration of vegetation; and long distances to dry season markets. The quality of social capital prior to the project was also described as very low, and women were particularly disadvantaged, excluded and marginalized.

Local communities have low awareness of their rights regarding natural resource management (NRM) and how to exercise them. Natural resources in Butana are under pressure from outside interests such as large-scale commercial farming, uncontrolled grazing and artisanal gold-mining. Climate change, in the form of increasing temperatures and less predictable rainfall, imposes additional pressure on already fragile agroecosystems.

Key NRM needs include (i) the ability to handle land disputes peacefully, which assumes that communal rights to land are recognized and enforced, especially vis-à-vis outside interests; (ii) the ability to regulate access to and use of land and water resources through, for example, payment for water or guarding community rangeland or forest land; and (iii) the development of organizational experience in managing community initiatives and NRM.

Description of nature-based solution

Communities need to be made aware of their rights and responsibilities with respect to accessing their natural resources and managing them sustainably. The NRGF provides a framework for identifying priorities and constraints through dialogue and negotiation with government agencies. Its creation involved an extensive consultative process around NRM, with many workshops and stakeholder forums conducted at four levels: community cluster (24 forums), locality (9), state (5) and interstate (1) levels. This process was interactive and was aimed at (i) discussing issues of land tenure and governance of natural resources; (ii) developing a common understanding of the root causes of range/forest degradation; (iii) ensuring that the voices of grassroots stakeholders are heard at higher levels; and (iv) agreeing on actions for addressing legislation issues and enhancing the enforcement mechanisms for better NRM.

Women must make up 50 per cent of the participants in consultation forums, and problems identified at the community level are escalated for action at the appropriate level of government. The interstate forum identified policies and the required legislation and instruments for their enactment and implementation.

Key results and impacts

NRGF implementation has resulted in key outcomes, including (i) the adoption of collective community protection of communal and government forests; (ii) incentives or salary payments for forest guards; (iii) communities registering their communal forests; (iv) documentation and activation of customary regulations related to NRM; and (v) collective action in resisting the establishment of a new ceramic factory. In addition, over 2,000 km of fire lines have been demarcated in community forests, and local orders have been issued to

prevent the encroachment of other activities on dryland fodder and to prevent land transactions for investment in land near the villages. The East Gezira locality issued a local order to regulate and resolve conflicts over land use between agropastoral and farming communities.

The establishment and functioning of community networks managing their landscapes together under a joint vision and land-use and development plans has resulted in more benefits for communities. Conflicts over resources have been resolved and the communities are seeking the legal recognition of their communal rangeland and forestland. Local women have been empowered through the establishment of women's committees and the women's village saving and credit clubs.

The consultative process led to an improved awareness of natural resource issues, which had a positive impact on resilience to drought and climate change. An impact assessment carried out in 2019 showed that 83 per cent of respondent households perceived enhanced resilience as one of the project's positive impacts.

This NbS also contributed to gender transformation in a conservative society: unlike in the past, women now actively participate in community meetings and assume leadership positions in community development committees and community networks, improving respect for women and their status and self-confidence.

Village networks with organized committees are now acting individually and collectively to improve social relationships, manage the natural resources at their disposal and reduce conflict over them, mobilize support for common initiatives to protect rangelands, build *hafirs* (artificially constructed water catchment basins) and venture into youth-led social enterprises. The NRGF thus clearly provides a range of social benefits and contributes to building local capacities, including for women.

Improved forest and rangeland management is also a main factor increasing carbon storage performance, with an estimated 2.3 tons of CO_2 equivalent sequestered per hectare per year for the BIRDP project as per the EX-ACT analysis, which ranked ASAP investments in Sudan first among 10 projects in terms of mitigation benefits (with a total of 4.7 million tons of CO_2 equivalent stored over 20 years, thanks to improved management of forests).

Limitations

The NGRF has taken a long time to develop, as it mobilizes many stakeholders at different levels. A further issue is its sector-focused government structure that impedes an integrated approach to problem-solving.

Sustainability of the NRGF approach in the absence of BIRDP is a key issue. The Federal Ministry of Agriculture and Forests has taken on the responsibility of implementing the NRGF's proposed policies and institutional and legislative arrangements. However, the civic–government engagement established through the NRGF needs to be strengthened and institutionalized, and the Butana Development Fund needs to become effective.

Lessons learned

The NRGF provided a structure that empowered people to discuss their interests and rights with respect to natural resources through local networks, and to pursue their priorities with authorities at different levels of government. Timelines are long in the development of new policies, institutions and regulations, and natural resource issues are often contentious.

The NRGF aimed to resolve some of the contradictions between customary rights and statutory laws, and it was found that there is more enforcement of laws and regulations at the local level than at higher levels of government.

The success of this NbS is due to the combination of a community empowerment process and other interventions, including improved access to resources/services and multifaceted capacity-building, which has led to improved livelihoods and food and nutrition security, and strengthened resilience and adaptation to climate change.

To reach its full potential it is important that the NRGF continues to be tested, further refined and scaled up, which is the aim of IFAD's follow-up Sustainable Natural Resources and Livelihood Programme, which was approved in September 2019.

Case study 3: The Gambia – strengthening coastal communities' livelihoods through mangrove restoration

NATURE-BASED SOLUTION PROFILE

PROJECT AREA

PROJECT: National Agricultural Land and Water Management Development Project (Nema-Chosso).

DESCRIPTION: Mangrove restoration was implemented as part of the watershed planning component of Nema-Chosso in Gambia. This NbS is aimed at making both environmental and socio-economic conditions more sustainable for local communities, while strengthening an ecosystem that plays a key role in terms of climate adaptation and mitigation, and biodiversity enhancement.

NbS TYPE: Coastal wetland restoration.

SPECIFIC NbS BENEFITS: Improvement of food production; improvement of incomes.

OTHER BENEFITS: Resilience to climate-related shocks; improvement of carbon and other GHG pools; enhancement of biodiversity.

DURATION: 2012-2020.

TOTAL PROJECT COST: US$76.59 million.

FINANCING: Government of The Gambia; domestic financing institutions; IFAD; ASAP Trust Fund; Debt Sustainability Framework; African Development Fund, Islamic Development Bank; beneficiaries.

TARGET GROUP: 23,560 smallholder households in all six agricultural regional directorates along the Gambia River.

Background and development challenge

Wetland and mangrove degradation have been major issues in past decades, partly owing to unsustainable NRM, namely woodcutting for purposes such as providing fuelwood and construction poles and wood for fish smoking. In addition, the construction of anti-salt dams and dykes led to salinization, acidification and mangrove dieback, resulting in dwindling fish stocks. Wetlands are often described as wastelands and are therefore used for dumping garbage or often reclaimed for housing. However, for communities along the Gambia River, mangroves represent a major source of revenue and livelihood. This ecosystem plays a vital role in the sustainability of the fisheries subsector.

The Gambia is highly vulnerable to climate change: in the short term, extreme climate events including windstorms, rainstorms, droughts and dust storms will become more frequent and increasingly

severe. Land-use and land cover change, sea level rise and coastal erosion present significant long-term challenges. Larger tidal volumes combined with higher soil salinity have deteriorated swamps across the region. Mangroves are particularly vulnerable to climate change. As temperatures and precipitation patterns change, broader tidal ranges are affecting mangroves throughout The Gambia and neighbouring countries.

Mangroves provide habitats for fish, oysters, mud crabs and clams, promoting food sources, fishers' incomes, biodiversity and maintenance of ecosystem functions. They also serve as fish nurseries, allowing water life reproduction and sustainability, and provide wood for small community practices such as fish-curing. Their vegetation retains sediments and filters run-off water, preventing coastal erosion and siltation. Moreover, mangroves moderate the climate: they can store CO_2 and their destruction may therefore release huge amounts of GHGs into the atmosphere.

Description of nature-based solution

The Nema-Chosso project has significantly invested in mangrove and forest restoration, partnering with the government as well as non-governmental institutions, as part of its overall strategy to promote adaptation and resilience.

The project targeted mangrove restoration through the regeneration of local mangrove species and the establishment of tree nurseries. Following a community-based approach, to ensure ownership and sustainability of the project, community groups identify the activities and project sites before submitting a proposal to the regional agriculture departments. During project implementation, populations from villages close to mangroves participate in an extensive training and mangrove regeneration exercise to restore degraded mangroves in their communities. Management committees have been formed and trained at each beneficiary site to manage the investment and ensure community participation and that relevant equipment and materials are provided.

Key results and impacts

Between 2016 and 2019, the project achieved the restoration of 1,458 ha of mangroves spread across 43 communities in the West Coast, Lower River, Central River and North Bank regions of the country. As the results quickly exceeded the initial targets, an additional 630 ha of mangroves is being restored.

This NbS shows a high level of satisfaction and ownership by the beneficiaries, who appreciate the investments made so far and are already seeing the benefits. Local people have observed that mangroves, fish and oyster stocks are regenerating fast in targeted areas.

Limitations

Tracking indicators such as fishing incomes or household diet diversity would help to provide more evidence of the impact of mangrove restoration on coastal communities' livelihoods and food security.

Mangrove restoration is likely to contribute to cooling microclimatic conditions in areas of often-high temperatures. However, such environmental benefits are difficult to measure.

Lessons learned

The active participation of local populations was critical to the success of this NbS. It has been promoted through intensive mobilization and training. Decentralized government agencies were also fully involved in the project, which is a promising sign for the sustainability of the project.

Mangroves located in protected areas have quickly regenerated thanks to the participation of the same communities that were previously contributing to its overexploitation. This highlights the importance of approaches that combine conservation measures with initiatives that ensure that local communities can access and benefit from protected area resources for their livelihoods.

Case study 4: Nicaragua – shade trees in croplands, a cross-cutting nature-based solution

NATURE-BASED SOLUTION PROFILE

PROJECT AREA

PROJECT: Adapting to Markets and Climate Change Project (NICADAPTA).

DESCRIPTION: The planting of shade trees in diversified croplands is a NbS implemented through NICADAPTA in Nicaragua. Through a combination of diversified agricultural systems [*sistemas agrícolas diversificados*] (SAD) and agroforestry systems [*sistemas agro forestales*] (SAF) approaches, it tends to benefit both environmental conservation/restoration and food security, and wood availability.

NbS TYPE: Trees in cropland.

SPECIFIC NbS BENEFITS: Adaptation to the long-term trends and effects of climate change; improvement of carbon and other GHG pools; enhancement of biodiversity.

OTHER BENEFITS: Soil conservation and improvement; improvement of food production; capacity-building.

DURATION: 2013-2020.

TOTAL PROJECT COST: US$37.05 million.

FINANCING: IFAD (including ASAP); Central American Bank for Economic Integration; Government of Nicaragua; beneficiaries.

TARGET GROUP: 120 coffee and cocoa producer organizations (around 20,000 households) in Jinotega, Matagalpa, Boaco, Madriz, Nueva Segovia, Estelí, Rio San Juan and the autonomous regions of the northern and southern Caribbean coast of Nicaragua.

Background and development challenge

Nicaragua is among the 10 nations worldwide that have been most impacted by extreme hydrometeorological events during the last 20 years according to the Global Climate Risk Index, and temperatures are expected to rise by 2-2.5°C by 2050. Coffee and cocoa are pillar crops for Nicaragua's economy and account for a large part of employment in rural areas.

This predicted rise in temperature threatens coffee and cocoa production systems, which will impact producers' income and food security. Higher ambient temperatures accelerate the ripening of coffee cherries, which decreases the quality of the product, while lower temperatures are required for growing high-value arabica coffee. Meanwhile variability in rainfall patterns is expected to affect the sustainability of cocoa crops by accelerating the evolution and reducing

the incubation periods of harmful organisms and modifying the geographical distribution of pathogens and pests.

Description of nature-based solution

This NbS is based on the introduction of trees (fruit, timber, musaceous – bananas and plantains) and/or crops (leguminous species), according to SAF approaches, and accounts for several cross-cutting agricultural and environmental benefits, including the following.

- Trees provide temporary shade (musaceous) and/or permanent shade (fruit and timber) for coffee and cocoa trees, maintaining temperatures at satisfactory levels in the plantations.
- The introduction of fruit or timber varieties allows crop diversification, enhancing household food security and/or meeting fuel needs.
- Trees significantly contribute to carbon capture.
- Trees provide ecosystem services such as soil conservation and organic matter renewal.
- Planting native species allows the promotion and conservation of local biodiversity.

Several models have been tested in NICADAPTA, for example:

(i) Plantain banana trees – cocoa (FIGURE 3) or coffee;
(ii) Leguminous and nitrogen-fixating tree species (guaba or *Inga* spp.) – coffee;
(iii) Timber species (e.g. granadillo, mahogany and cedar) – cocoa or coffee;
(iv) Fruit species (e.g. lemon trees, orange trees, avocado trees) – cocoa or coffee.

To enhance soil conservation, leguminous cover crops have also been introduced in cropping systems: planting cowpea and *Canavalia* and *Mucuna* spp. in between coffee/cocoa plants can maximize nitrogen fixation and these crops can be used as green manure. These varieties are characterized by a high germination rate and good soil coverage.

The NbS presented here is perfectly in line with national climate plans in the sense that it combines both SAD and SAF approaches, proposing adaptation and mitigation practices to climate change, while reinforcing food security and ensuring land conservation. This was one of the main objectives of the project when using ASAP funds.

FIGURE 3. Plantain–coffee mixed cropping in Nicaragua

Key results and impacts

As a result of the project, around 1,900 ha of cocoa were established in combination with shade species, and 4,344 ha of coffee were established with the same combination of shade species.

Around 80,000 plants of *Musaceae* were planted in cocoa and coffee plantations (data from 2018). Leaves are cut to provide organic matter for the soil when the shade is no longer necessary, enhancing the soil structure. *Musaceae* are also natural hosts of a cocoa-pollinating fly.

Over 30,000 plants of fruit varieties (2018) and around 20,000 plants of timber species were planted. Leguminous trees also provide rich organic matter that enhances soil quality and nutrient availability for crops. Soil cover crops such as cowpea have been used by four producer organizations; over 4,000 kg of seeds were distributed.

With the introduction of trees in the coffee and cocoa plots, this NbS contributes to the recovery of degraded areas and the reduction of risks related to water deficits, landslides and damage from extreme meteorological events.

In addition to contributing to household food security, this NbS allows income diversification, strengthening households' resilience.

As per EX-ACT data, NICADAPTA accounts for an estimated 188,341 tons of CO_2 equivalent sequestered over 20 years. Nicaragua's agroforestry and cropland restoration activities generate one of the highest-density impact potentials in the ASAP portfolio, at 2.7 tons of CO_2 equivalent sequestered per hectare per year.

So far, 66 per cent of the producers have taken up and implemented this NbS, to establish the basic conditions for coffee and cocoa crops to adapt to the new climatic conditions in the project area. Training sessions involving 14 organizations attracted 56-76 per cent of the farmers.

Limitations

The key constraint is that there is no explicit evidence of how diversification of shade types increases resilience and reduces climate risks for coffee and cocoa crops. Measurements will be carried out after the end of the implementation phase.

Lessons learned

SAF and SAD implementation, combined with the dissemination of cocoa/coffee varieties that are climate change resistant, developed by the Government of Nicaragua, are at the core of the project. The combination of these two practices has made it possible to extend coffee/cocoa plantations where it was previously not possible to cultivate because of adverse weather conditions, while increasing crop productivity – rather than advocating a shift from one cropping system to another. Gardens and nurseries were established to expand the scale and increase the provision of these climate-resistant varieties to producers.

The project has also resulted in the introduction of disease-resistant species that therefore fully fulfil their role as shade providers.

Case study 5: Lao People's Democratic Republic – enhancing soil fertility and pest management with effective micro-organisms

NATURE-BASED SOLUTION PROFILE

PROJECT AREA

PROJECT: Southern Laos Food and Nutrition Security and Market Linkages Programme (FNML).

DESCRIPTION: In the Lao People's Democratic Republic, effective micro-organisms (EM) is an NbS set up through FNML that contributes to improving soil fertility in vegetable gardens (and croplands) and reducing pest/insect invasion. EM is composed of various blends of common predominantly anaerobic micro-organisms that positively influence the growth of plants (Olle and Williams, 2013).

FNML's goal is to contribute to reducing extreme poverty and hunger. It is implemented in three southern provinces (and five districts among the poorest and most remote in the country): Attapeu (Sanxay and Phouvong districts), Salavan (Ta Oi and Samuoi districts) and Xekong (Dak Cheung district). It targets a total of 175 villages that combine conditions of poverty with production and market potential. Women constitute a key target group to ensure their equal or priority access to programme benefits.

NbS TYPE: Soil fertility and pest management.

SPECIFIC NbS BENEFITS: Soil conservation and improvement; improvement of food production; capacity-building.

OTHER BENEFITS: Local job creation.

DURATION: 2013-2020.

TOTAL PROJECT COST: US$79.43 million.

FINANCING: National government; IFAD (including ASAP); Asian Development Bank; private sector; beneficiaries.

TARGET GROUP: Populations of 175 target villages combining poverty with production and market potential. Women constitute a specific target group within the main target group to ensure their equal or priority access to programme services and benefits. Young men are also an important target group because of their potential to increase household income levels.

Background and development challenge

Agriculture remains the primary source of subsistence and employment in the rural areas of the Lao People's Democratic Republic. This sector has a number of weaknesses: low access to inputs, finances, markets, support services and technologies; low productivity; and income per

capita of less than half the national average. The country is one of the most vulnerable to climate change in South-East Asia, mainly because of its high dependence on climate-sensitive natural resources and its low adaptive capacity, which further undermines farmers' food and nutrition security as well as their potential to produce marketable surpluses. Ethnic minorities are among the most food-insecure, and undernutrition is alarming, with 44 per cent of children under 5 years of age affected by stunting (IFAD, 2019a).

Smallholder farmers usually practice household gardening to increase food security and nutrition and generate an income. In vegetable gardens and croplands, many have experienced low soil nutrient content and outbreaks of pests and diseases, which considerably reduce yields. To increase production, farmers often apply chemical fertilizer to the soil in combination with animal compost, however chemical fertilizers have adverse effects on soil fertility. The IFAD FNML Programme introduced use of an EM solution technique that improves soil production capacities and enhances yields of garden crops and vegetables.

Description of nature-based solution

EM is a bioextracting technique based on vegetable waste materials. It is created by combining specific micro-organisms that work together synergistically, such as lactic acid bacteria, yeast and phototrophic bacteria. It activates local and native micro-organisms that live in soil (and water) and maximizes their natural ability, by restoring a healthy balance of micro-organisms in the soil ecosystem. The EM mixture ferments organic matter in the soil to help activate other beneficial micro-organisms. When desirable micro-organisms increase in number, other living things such as worms increase along with them.

FIGURE 4. Waste from vegetables, sugar and molasses

©IFAD/WOCAT

Farmers use vegetable waste such as cabbage, pineapple, spinach and mustard, together with sugar and molasses, in the following proportions: 3 kg of chopped vegetables, 1 kg of sugar and 0.5 litres of molasses (a by-product of sugar refining) (FIGURE 4). The mixture is sealed in a 20-litre tank and stored in the shade for 1 week. It is then opened, mixed again and stored again in the shade for up to 1 month. Thereafter, the EM mixture is ready for use: one tablespoon is to be added to 10 litres of water (the compost is soup-like) and, once this has been well mixed, it can be applied to the vegetables in the home garden (or in cropland).

Key results and impacts

The EM mixture is easy to produce, as it can be based on any type of vegetable waste and is prepared using a simple process. It does not harm the environment or human health.

It has been noted that, after the application of the EM solution, the number of earthworms around the vegetable plots increases, while plant pathogens and pests/insects (such as red ants and leaf worms) are significantly reduced. Furthermore, marked increases have been noted in both soil moisture and nutrients: the soil, relatively white and compacted before application of the EM mixture, becomes black and porous, allowing good water seepage and avoiding water run-off over the surface.

The EM mixture improves the growth, quality, diversity (EM application boosts the production of all varieties of vegetables) and yield of vegetables grown. Before using the EM mixture, farmers used to harvest 5-6 kg of vegetables per plot; using the mixture they are now able to harvest 12-15 kg per plot without having to use expensive chemical fertilizers.

Use of the EM mixture has resulted in increased household incomes and improved food security and nutrition, as the vegetables produced are

both consumed by those who produce them and sold at local markets.

Limitations

It was noted that the EM mixture may favour grass/weed growth (such as *Eleusine indica* in the targeted areas). These plants are not easy to control, requiring an increase in working hours for weeding.

Lessons learned

This method is efficient and easily reproducible, and is implemented easily by women and men to improve soil health and vegetable yields. It has only been used on a small scale, so the results of EM use have not yet been reliably reported. More emphasis on the uptake of this method is required and more time is required to properly analyse the impacts and implications for other ASAP programmes.

Case study 6: Ethiopia – watershed management, a broad-based approach to sustainably rehabilitate and conserve soil and water resources

NATURE-BASED SOLUTION PROFILE

PROJECT AREA

PROJECT: Participatory Small-scale Irrigation Development Programme phase II (PASIDP II).

DESCRIPTION: In Ethiopia, watershed management is an NbS set up through PASIDP II. It contributes to sustainably increasing soil fertility and productivity and protecting irrigation schemes from sedimentation.

PASIDP II covers four regions (Amhara, Oromia, Southern Nations, Nationalities, and Peoples' Region, and Tigray), targeting 68 food-insecure districts (*woreda*). Watershed management practices implemented in PASIDP II include various activities: training on watershed management; development of microwatershed management plans; biophysical soil and water conservation measures; establishment and strengthening of tree nurseries.

NbS TYPE: Watershed management.

SPECIFIC NbS BENEFITS: Adaptation to the long-term trends and effects of climate change; resilience to climate-related shocks; preservation of freshwater resources; soil conservation and improvement; improvement of food production; capacity-building.

OTHER BENEFITS: Improvement of carbon and other GHG pools; enhancement of biodiversity; improvement of incomes; gender equality and women's empowerment.

DURATION: 2016-2024.
TOTAL PROJECT COST: US$153.15 million.
FINANCING: Government of Ethiopia; IFAD (including ASAP); Alliance for a Green Revolution in Africa; beneficiaries.

TARGET GROUP: 480,000 men and women (targeted in a ratio of 49:51 per cent) from poor smallholder households.

Background and development challenge

Key challenges in Ethiopia include soil degradation, deforestation and loss of biodiversity, as well as weak environmental management and enforcement capacity. Moreover, climate change projections for the country indicate that there will be a significant increase in temperature and limited water availability, and a likely increase in drought occurrences, heavy rains and floods. Smallholder farmers in particular are exposed to these challenges, as they directly rely on climate-affected natural resources for their livelihoods and inhabit vulnerable and marginal landscapes such as hillsides and deserts.

Description of nature-based solution

Training on watershed management targeted farmers, trainers and federal and regional experts and covered biophysical soil and water conservation techniques, community-based participation, geographical information systems and Earth observation for agriculture and rural development.

Microwatershed management plans are based on identification and prioritization of biophysical and socio-economic issues as well as proposals for alternative technologies for communities that improve land production and productivity at a microwatershed level. At midterm review, about half of the microwatershed management plans developed had been formalized with maps of location, land use land cover, soil type and slope, and a development plan map had been prepared using geographical information system tools, which represents about 49,990 ha of land under different climate resilience practices (FIGURE 5).

Biophysical soil and water conservation techniques include bund construction, trench formation, gully rehabilitation, and grass strip and tree planting, based on conservation agriculture and agroforestry approaches. These techniques allow the restoration of the watershed and contribute to ecosystem services such as provisioning, regulating and supporting services (soil structure formation, nutrient cycling, and primary production of crops and fodders). They have been implemented on private and communal lands and the species planted come from nurseries supported by the programme.

Nurseries have promoted various tree species (e.g. *Cordia africana*, *Sesbania sesban*, *Leucanea leucocephala*, *Acacia polyacantha* and *Croton macrostachyas*) to simultaneously ensure the sustainability of the watershed by enhancing soil fertility and biodiversity; the diversification of farmers' income (ensuring that income-generating activities are mostly handled by women); and the improvement of the nutritional status of local communities.

Key results and impacts

The results of the project showed that community members appreciated the training provided by the PASIDP II team, which effectively supplemented their traditional knowledge; the plans developed are comprehensive; the watershed management committees were functional (in the sites visited during the supervision mission) and contributed to raising awareness and to sensitizing other community members about the benefits of watershed management; and more than 80 per cent of trees planted have survived. The way in which watershed management was implemented has strong potential for scaling up.

There is scope to further improve sustainable watershed management by strengthening the promotion of sustainable biological erosion control measures such as grass strips; engaging the community further during the selection of the appropriate measures; and promoting soil fertility improvement measures and water use efficiency. Impacts have not directly been assessed by the programme.

Limitations

More training is required to make use of the mapping capacity to further the implementation of watershed management plans and to illustrate the interdependency of communities.

Limited skills training has been provided on analysing details of land use, land cover and biomass productivity. Thus, additional practical field training should be provided to technical staff that builds on work from the initial stage to enable them to evaluate the impact of the programme.

Lessons learned

The trenches are labour-intensive, less sustainable than other methods and require resources. Grass strips on the other hand are more sustainable, as they need less maintenance, can contribute to terracing, are a source of feed for livestock and are easy for women to implement. Consequently, more focus should be placed on biological solutions such as grass strips, including the use of vetiver species that can be used on steep slopes.

Moreover, other tree species should be promoted such as neem (*Azadirachta indica*) and *Faidherbia albida*, along with fruit trees, and benefits of these tree species should be further explained to communities to incentivize adoption.

Case study 7: Niger – land management to enhance productive capacities and improve resilience of smallholder farmers

NATURE-BASED SOLUTION PROFILE

PROJECT AREA

PROJECT: Family Farming Development Programme [Programme de développement de l'agriculture familiale] (ProDAF) in the Maradi, Tahoua and Zinder regions.

DESCRIPTION: In Niger, land restoration set up through ProDAF has enabled the conservation and restoration of natural resources, such as soil and water; adaptation to climate change; and the enhancement of productive capacities on agricultural and pastoral lands, improving the resilience of small-scale producers.

The overall objective of ProDAF is to contribute to sustainable food and nutrition security, and improved resilience of rural households in the Maradi, Tahoua and Zinder regions. To increase farmers' incomes on a sustainable basis, as well as their resilience to shocks, particularly climate-related shocks, the project has supported the rehabilitation of

22 watersheds through the implementation of various NbS, all contributing to soil and water conservation.

NbS TYPE: Land management.

SPECIFIC NbS BENEFITS: Adaptation to the long-term trends and effects of climate change; resilience to climate-related shocks; improvement of carbon and other GHG pools; preservation of freshwater resources; soil conservation and improvement; improvement of food production; capacity-building.

OTHER BENEFITS: Enhancement of biodiversity; improvement of incomes; local job creation; gender equality and women's empowerment.

DURATION: 2015-2023.

TOTAL PROJECT COST: US$110.66 million.

FINANCING: Government of Niger; IFAD (including ASAP); Government of Italy; the Organization of the Petroleum Exporting Countries Fund for International Development; Global Environment Facility; beneficiaries.

TARGET GROUP: 240,000 households involved in agro-silvo-pastoral activities, targeting 30 per cent of women and 30 per cent of young people.

Background and development challenge

ProDAF target areas are characterized by land degradation and high vulnerability to food insecurity, malnutrition and climate change. These areas include arable land that has been severely degraded by water and wind erosion. The dominant farming systems are extensive agropastoral rainfed production systems based on cereal crops, gardening and rangeland grazing.

Description of nature-based solution

A combination of mechanical treatments (water and soil conservation techniques and removal of invasive plants such as *Sida cordifolia*) and biological treatments (planting grasses and trees) were implemented to restore degraded land and improve agricultural and livestock production systems (table 5). The development of the social and organizational skills of village committees is an integral part of the project because it ensures the sustainability of these activities.

Cash for assets systems address food and livelihood needs through cash transfers, while creating a healthier natural environment in the long term, reducing the risks and impacts of climate-related shocks, increasing food productivity and strengthening resilience to natural disasters through building or rehabilitating natural assets.

FIGURE 5. Example of intervention in a gully (left) and grass strips (right) in Amhara region, 2020

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TABLE 5. Overview of the NbS used in ProDAF and results to date against project targets

NbS NAME	NbS DESCRIPTION	NbS RESULTS TO DATE AGAINST PROJECT TARGETS AND ILLUSTRATION (IFAD, 2019b)
Dune fixation by planting trees	Planting of local tree species (e.g. *Euphorbia spp.*) in successive lines, perpendicular to dominant winds, to protect cropland.	1,525 ha (target 1,950 ha) 
Assisted natural regeneration	Protection of trees growing naturally in cropland, mainly involving the protection of fertilizer trees such as *Acacia albida* or trees protecting against insects, such as *Piliostigma reticulatum*, in millet fields. The trees also act as windbreaks and protect against extreme temperatures.	118,630 ha (target 193,425 ha) 
Soil and water conservation measures	Measures to conserve and restore soil and water: *zaï*, a farming technique consisting of digging pits (10,000 per hectare) in degraded land to concentrate organic matter and capture water; stone lines, anti-erosion devices consisting of blocks of stone arranged in rows in the fields; and living fences, hedgerows of tree or herbaceous species able to propagate easily and grow quickly.	*Zaï*  Stone lines  Living fence 

NbS NAME	NbS DESCRIPTION	NbS RESULTS TO DATE AGAINST PROJECT TARGETS AND ILLUSTRATION (IFAD, 2019b)
Restoration of pastoral rangelands and corridors	Clearing land of invasive species *(Sida cordifolia)* through cash for assets systems, and planting grasses of forage interest *(Eragrostis tremula sp., Cenchrus biflorus sp., Cassia tora, Zornia glochidiata, Cenchrus biflorus, Eragrostis tremula, Alysicarpus ovalifolius, Panicum leatum, Tephrosia linearis)* and sometimes trees *(Moringa oleifeira, Adansonia digitata, Balanites aegyptiaca, Acacia senegal, Acacia nilotica, Ziziphus mauritiana)*. The use of fodder plants is discussed and encouraged in the livestock innovation schemes.	Development of transhumance corridors and silvo-pastoral areas: 1,735 ha (target 2,500 ha) 
Pastoral half-moons	Digging water-harvesting semi-circular holes (2-3 m wide) to help with biomass regeneration. Around 300 half-moons were dug per hectare; they act as a water reservoir for planted trees (local species such as *Acacia spp.* and *Balanites spp.*) and enable grass regeneration.	
Multi-local-species tree nurseries run by women	Vulnerable women are selected and trained to create and run tree nurseries housing local species. Trees are sold and used for various purposes (e.g. for planting on pastoral half-moons or associated agroforestry practices).	

Key results and impacts

At its midpoint, ProDAF had rehabilitated 101,000 ha of degraded land through these land restoration measures, which were adopted by 50-85 per cent of the targeted communities. The immediate effect is the reduction of erosion, enabling the recovery of degraded land and an increase in arable land. Assisted natural regeneration and hedgerows also help to reduce evapotranspiration and act as windbreaks.

The project resulted in significant average yield increases, of around 40 per cent for irrigated crops (e.g. onion, cabbage and tomato) and over 30 per cent for all rainfed crops, with particularly impressive increases for millet (78 per cent), sorghum (63 per cent) and cowpea (53 per cent). In addition, these measures have co-benefits in terms of mitigation (increasing carbon sequestration in the vegetation and soils) and biodiversity (creation of new and diverse habitats).

Rehabilitation of pastoral areas and transhumance corridors reduces the risks of conflicts between farmers and herders by reducing grazing competition. When selecting areas to be rehabilitated, it is important to maintain the continuity of the transhumance corridors to ensure positive results. In addition, by developing nurseries and selling tree seedlings, women have access to an additional source of income, which is mainly used to purchase small livestock. This has a positive impact on the nutrition status of their children (through milk consumption) and is a traditional form of savings. It also contributes to strengthening women's participation in decision-making.

Farmer field schools and farm advisory services for farmers have been assessed as positive tools. They have presented land restoration techniques together with other techniques, including different NbS adapted to climate change: composting; biopesticide production (based on neem leaves); and the promotion of local diversified seeds. Adoption rates of these climate change adaptation techniques are significant: 87 per cent for the use of short-cycle seeds, 60 per cent for composting and 47 per cent for assisted natural regeneration. ProDAF plans to amplify the assisted natural regeneration practice in all areas involved with the farmer field schools/farm advisory services for farmers extension system, that is, an area of 190,000 ha at the level of rainfed farming.

Another impact of this NbS concerns the organization of site management committees (e.g. guards monitoring NbS implementation), who also contributed to these positive results. In the Tahoua region, the agricultural areas increased by 10,000 ha, increasing the average field size from 0.6 to 2.2 ha per farm (IFAD, 2019c). In land restoration areas in the Maradi region, the biomass increased by 76 per cent compared with 2017 (CNSEE, 2017), increasing carbon storage. After four years, the project had enabled the mitigation of an average of 1.2 tons of CO_2 equivalent per hectare per year, estimated with the EX-ACT.

Constraints and limitations

The production of an extensive database would allow analysis of the impact of the changes on water resources and soil fertility, as well as people's resilience to climate change.

The tree survival rate is about 50 per cent, with three years of full guarding (including the dry season). Guarding is a strong constraint; however, it is absolutely necessary to ensure tree growth.

The sustainability of the new extension system created is also a key challenge. For the greatest impact it must be properly embedded in the national extension framework and obtain long-term funding.

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