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R I V E R   P A R T N E R S

APPLYING ECOSYSTEM-BASED DISASTER RISK REDUCTION (ECO-DRR) IN INTEGRATED WATER RESOURCE MANAGEMENT (IWRM)

IN THE LUKAYA BASIN, DEMOCRATIC REPUBLIC OF THE CONGO

CADIM .a.s.b.l
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Intégral/Mbankana

REGIDESO S.A.
RÉGIE DE DISTRIBUTION D'EAU
DE LA RÉPUBLIQUE DÉMOCRATIQUE
DU CONGO

RIVER PARTNERS

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TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

More than half of Africa's
freshwater resources lie
within the borders of the DRC

*Reference: UNEP (2011) Water Issues
in the Democratic Republic of the Congo
Challenges and Opportunities: A technical Report.
http://postconflict.unep.ch/publications/UNEP_DRC_water.pdf*

In 2013-2016, the United Nations Environment Programme (UNEP) and the European Commission (EC) supported a pilot demonstration project on Ecosystem-based Disaster Risk Reduction (Eco-DRR) in the Democratic Republic of the Congo (DRC). Implemented in partnership with the National Government, the Lukaya River Users Association (AUBR/L), and other local partners, the Eco-DRR project aimed to reduce flood and gully erosion risks and support community livelihoods through applying Integrated Water Resource Management (IWRM) in the Lukaya River basin, located in the outskirts of the capital Kinshasa.

The Eco-DRR project built-on and closely complemented an integrated catchment management demonstration project in the same basin, which was carried out by UNEP with support from the UN Development Account (2013-2016). Activities of both projects were implemented in a joint and integrated manner, although the stress on specific principles differed based on each project's respective aims and plans. It was DRC's first experience of applying IWRM, which was tailored to the local needs of the DRC. The project also served as a model for demonstrating how IWRM provides an effective framework for promoting Eco-DRR concepts and measures.

The project had four main components:

(i) Mainstream Eco-DRR in the development of an IWRM Action Plan for the Lukaya River basin;

(ii) Undertake field interventions, including reforestation, agroforestry and gully erosion control through bioengineering techniques;

(iii) Develop local and national capacities for implementing Eco-DRR through IWRM;

(iv) Support national advocacy on Eco-DRR through IWRM.

The project clearly demonstrated that Eco-DRR can be successfully applied through an IWRM framework. An IWRM Action Plan for the Lukaya River basin has been developed that clearly promotes Eco-DRR measures, including agroforestry, reforestation and the continuous monitoring of soil erosion, river flows and flood risks. The overall success of the field demonstrations is evident by the strong community up-take of the interventions for their multiple benefits, including soil stabilization, flood and gully erosion risk reduction, as well as boosting agricultural yields and household incomes.

Strengthened collaboration between community-based organizations and National Government technical agencies ensure that project processes are sustained and supported by national institutions. Enhanced national awareness of the importance of Eco-DRR and IWRM has resulted in a stronger national advocacy agenda on both water resource governance and disaster risk reduction, also giving greater visibility of DRC's new experience and capacities on implementing Eco-DRR through IWRM in various regional and global fora.

PROJECT HIGHLIGHTS

The project promoted ecosystem-based measures to mitigate hazards, namely gully erosion and floods and address ecosystem degradation, which is a driver of disaster risk in the Lukaya River Basin. The project also served to reduce local vulnerabilities by implementing measures that:

- **Diversified local livelihoods and augmented household incomes;**
- **Developed local and national capacities to undertake Eco-DRR through IWRM implementation, including establishing local risk monitoring systems;**
- **Informed development policies and planning processes at local and national levels;**
- **Strengthened partnerships and collaborative initiatives on Eco-DRR.**

By bringing different stakeholders together, the IWRM planning process openly recognized the multiple and conflicting priorities for water and land use, and supported different river users to work towards a shared development vision for the Lukaya River basin. A number of Eco-DRR interventions, such as agroforestry, have been replicated independently in the Basin. A key ingredient of success was the sustained participation of local river users, through the AUBR/L. Women, as community leaders, farmers and income earners, demonstrated high interest and showed strong engagement throughout the project. Several women in local leadership positions, played an influential role in Eco-DRR activities.

We can reflect on a number of factors that support long-term outcomes:

- The project has developed sufficient local capacities through the AUBR/L to undertake and manage agroforestry, reforestation, vetiver bioengineering systems, so they can continue to deliver long-term benefits to households;
- The IWRM Action Plan provides a clear roadmap for AUBR/L to initiate new partnerships and mobilize additional resources;
- AUBR/L has now strong ties with National Government institutions and universities, which help ensure continued support from multiple partners;
- There is now greater awareness and commitment from the National Government to promote Eco-DRR through IWRM, based on national and regional exchanges and official statements delivered in various global policy fora, particularly in the run-up to the Third World Conference on Disaster Risk Reduction in March 2015, in Sendai, Japan.

HIGHLIGHTS OF INTERVENTIONS

- **Four tree nurseries were established** producing 42,000 seedlings (forestry and fruit trees) per year.
- **Community agroforestry system was established on** over 15 ha and will be expanded through a benefit sharing and revolving fund system. This system was introduced for the first time in DRC and has unique, innovative features.
- **Vetiver bioengineering was pioneered** in the Lukaya River Basin to reduce gully and river bank erosion. Four vetiver nurseries have been established, producing 32,000 vetiver plants per year.
- **A green buffer zone was established at the REGIDESO water treatment plant** in Kimwenza to reduce river bank erosion and sedimentation.
- **Reforestation on slopes** (7 ha), as well as green walls around houses.
- **71 trainings and workshops on mainstreaming Eco-DRR through IWRM were delivered** targeting local, national and regional actors.
- **Local risk monitoring systems were established** and linked to the national monitoring system. The river gauging stations are reportedly the only functioning stations in the DRC. **Soil erosion monitoring was pioneered** in the Mafumba sub-watershed. **Initial soil erosion and flood risk modelling** have been undertaken. National and local partners are trained to expand modelling work with new data being collected locally.
- **Eco-DRR has been mainstreamed** in the IWRM Action Plan of AUBR/L.
- **AUBR/L has been strengthened and restructured** into functional sub-committees and has gained legal status, more visibility and legitimacy.
- **An action plan to formulate the National Policy for Sustainable Water Resources Management** was developed, which highlights Eco-DRR and IWRM.
- **National Government of DRC engaged in regional and global consultations leading up to the endorsement of the Sendai Framework on Disaster Risk Reduction (2015-2030)**, and strongly promoted Eco-DRR through IWRM.

4 TREE NURSERIES WERE ESTABLISHED PRODUCING **42,000** SEEDLINGS PER YEAR

1 INTRODUCTION TO THE ECO-DRR PROJECT IN DRC

The DRC's forests play an
important role in regulating
freshwater resources
and mitigating floods

The European Commission and UNEP collaborated on a four-year project (2012-2016) to promote, innovate and scale-up ecosystem-based disaster risk reduction (Eco-DRR) in vulnerable countries and to raise greater recognition of Eco-DRR globally. While the project was global in scope, it implemented Eco-DRR pilot demonstrations in four countries: Sudan, Afghanistan, Haiti and the Democratic Republic of the Congo (DRC).

These four countries were selected because they presented four distinct ecosystem zones located in highly vulnerable settings, in which to apply various Eco-DRR approaches. In addition, UNEP has established field presence in all four countries, providing opportunity to leverage resources and build on UNEP's work in the countries.

In each of the four countries, the project delivered a common set of interventions, which were then tailored according to local contexts and national priorities.

These interventions included:

- National and community baseline assessments for mapping Eco-DRR opportunities and challenges;
- Field-based activities to apply and demonstrate the Eco-DRR approach and provide direct benefits to local communities, who are vulnerable to disaster and climate risks;
- Local and national capacity building and training workshops to support Eco-DRR implementation and promote replication of similar initiatives around the country;
- Strengthening partnerships and new collaborations on Eco-DRR; and
- Policy advocacy to inform national policy and planning processes and promote risk-informed, sustainable development.

This case study documents the experience, results and lessons of the Eco-DRR demonstration project in the DRC, which was implemented in the Lukaya River basin (**MAP 1**). The Eco-DRR project closely complemented another UNEP demonstration project on Integrated Water Resource Management (IWRM), which was implemented in the same basin and carried out with support from the UN Development Account (2013-2016).[1] IWRM, also referred to as integrated river basin or catchment management, aims to use water resources in a way that balances social and economic needs and protects ecosystems for future generations.[1]

It has been well-recognized in the global literature that IWRM provides an effective framework for promoting and implementing Eco-DRR. Therefore, this Eco-DRR demonstration project in DRC provided an excellent opportunity to apply the Eco-DRR approach within an IWRM framework. Activities of both projects by UNEP were implemented in a joint and integrated manner, although the stress on specific principles differed based on each project's respective aims and plans. The IWRM project provided DRC with its first practical experience of IWRM in the country. At the same time, it introduced a number of innovations to the IWRM approach, including a principal role for local communities, as well as applications for disaster risk reduction. As a result, both the IWRM and Eco-DRR projects mutually supported each other in delivering project benefits and maximized the use of resources.

A collaboration between the Government of DRC, UNEP, and local actors and communities, the Eco-DRR project aimed to reduce flood and gully erosion risks by promoting improved ecosystem management within an IWRM framework in the Lukaya River basin. Over 100 representatives from the Government, communities and the private sector engaged in the process, linking upstream and downstream water users. The project was also timely because it provided tangible experiences from the DRC, which helped inform national policy dialogue on the National Water Policy and the Sendai Framework for Disaster Risk Reduction (2015-2030). The IWRM experience in DRC, with its strong emphasis on Eco-DRR, is now being considered for replication in other basins in the country, as well as in the Central African region.

[1] *The UNDA supported project titled 'Promoting integrated water catchment management to improve urban drinking water supply in the DR Congo and the Central African region' specifically focused on protecting urban drinking water supply and improving community livelihoods. It also actively sought to share the project's lessons and experience in the sub-region.*

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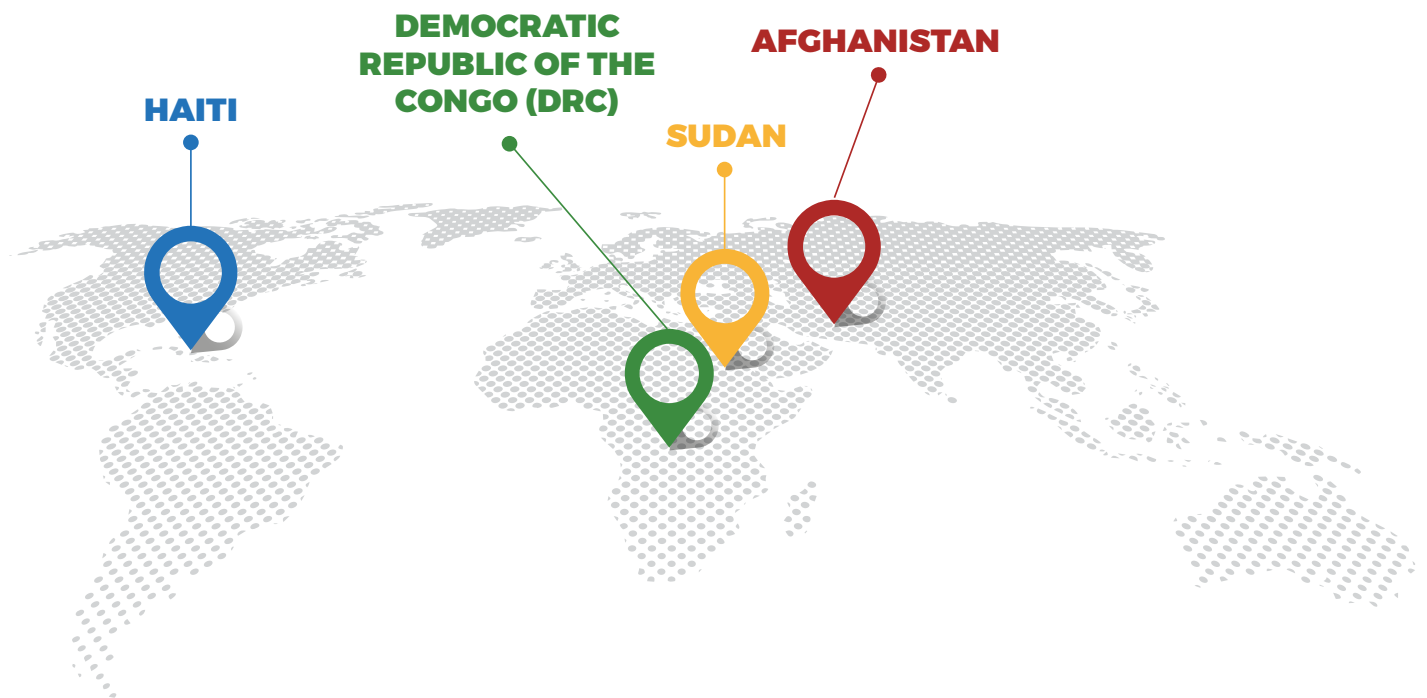
Click above or visit http://bit.ly/2ez99hQ to view a video of the Eco-DRR project in the Lukaya Basin

BOX 1. WHAT IS ECOSYSTEM-BASED DISASTER RISK REDUCTION?

Healthy, well-managed ecosystems have long been recognized to deliver multiple services, including for disaster risk reduction (Renaud et al. 2013). However, it is only over the last decade that the role of ecosystems in disaster risk reduction (DRR) has received increased global attention. Sustainable ecosystem management for DRR is now recognized as a priority measure in the Sendai Framework for Disaster Risk Reduction (2015-2030).

Ecosystem-based approaches to disaster risk reduction (Eco-DRR) have been defined as "the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim of achieving sustainable and resilient development" (Estrella and Saalismaa 2013: 30). With climate change expected to magnify existing disaster risks, Eco-DRR also incorporates climate risk management and climate change adaptation as a core principle (Ibid) and shares common features with Ecosystem-based Adaptation (EbA) (UNEP 2015).

Disaster risk is often understood as a composite of three main elements that must be present: hazards (e.g. flood, storm, landslide), exposure (i.e. people or assets located in hazardous locations) and vulnerability (i.e. the range of factors – social, physical, economic, environmental, cultural and political/institutional, etc. – that shape how hazards affect or impact on people and communities) (UNISDR 2009). Therefore, a reduction in any one of these elements will contribute overall towards disaster risk reduction (DRR).

If managed wisely, ecosystems, such as wetlands, forests, mangroves, reefs, seagrasses and dunes, perform important functions that can influence all three elements of the disaster risk equation – *by preventing, mitigating or regulating hazards* (e.g. forests can reduce incidence of landslides and avalanches, wetlands help regulate flooding and droughts), *by acting as natural buffers and thus reducing people's exposure to hazards* (e.g. mangroves, coral reefs and seagrasses protect coastal areas from storm surge impacts), and *by reducing vulnerability to hazard impacts* through supporting livelihoods and basic needs (food, water, shelter, fuel) before, during and after disasters (PEDRR 2013). In this regard, healthy, well-functioning ecosystems strengthen local resilience against disasters and climate change.

Eco-DRR builds on existing sustainable ecosystem management principles and approaches and includes a range of potential measures, such as: environmental impact assessment tools, integrated water resources management or river basin management, integrated coastal zone management, ridge-to-reef and other landscape-scale approaches, sustainable dryland management, protected area management, integrated forest management, among others (see PEDRR 2010). Eco-DRR should be implemented as part of broader disaster and climate risk management strategies, together with other measures such as engineered infrastructure when appropriate, risk-informed land-use planning, early warning and contingency planning.

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BOX 2. OVERVIEW OF THE ECO-DRR PROJECT IN DRC

PROJECT AIMS:
- To demonstrate the effectiveness of Eco-DRR through IWRM, in reducing the risks of floods and gully erosion and providing multiple benefits for local livelihoods;
- To develop local and national capacities for implementing Eco-DRR through a river basin management approach;
- To inform national policies and planning on mainstreaming Eco-DRR through IWRM.

ECOSYSTEMS IN FOCUS: River basin, high rainfall savanna with gallery forests

MAIN HAZARDS TARGETED: Floods and soil / gully erosion

TARGET BENEFICIARIES: 1,400 inhabitants (Ntampa, Kasangulu, Kimwenza and Mafumba zones of the Lukaya Watershed) out of a total population of 80,000 in the Lukaya River basin

IMPLEMENTING PARTNERS: the Centre for Integrated Development Support/Mbankana (CADIM), Association of the Users of the Lukaya River Basin (AUBR/L), The Vetiver Network

OTHER KEY PARTNERS: Technical Directorate of Water Resources (DRE) of the Ministry of Environment, Nature Conservation and Sustainable Development (MECNDD), the public water supply company (REGIDESO) of the Ministry of Energy, the Meteorological and Satellite Remote Sensing Agency (METTELSAT), Network for Natural Resources (RRN), General Commission for Atomic Energy / Regional Centre for Nuclear Studies in Kinshasa (CGEA/CREN-K), University of Kinshasa, and the Regional School for Integrated Forest and Land Management (ERAIFT).

DURATION: May 2013 – May 2016

BUDGET: [2] USD 310,000

OTHER ONGOING PROJECTS/ACTIVITIES LEVERAGED: UN Development Account funding amounting to USD 390,000 USD (2013-2016); technical assistance provided by UNEP-DHI Centre for Water and Environment.

[2] *This does not include UNEP staff and field office costs.*

UNEP worked in close collaboration with National and Local Government partners, AUBR/L, CADIM and other NGOs and local community representatives to implement the Eco-DRR project

MAP 1. Lukaya River Basin is located southwest of the capital, Kinshasa, in the Democratic Republic of the Congo

NIGERIA

CHAD

SUDAN

SOUTH SUDAN

CENTRAL AFRICAN REPUBLIC

Koukourou

Ouham

Lom

Sanaga

Uele

Kibali

CAMEROON

Kad??

Sangha

Ubangi

Congo

Busira

Lualaba (Congo)

Tshuapa

UGANDA

Semliki

GABON

REPUBLIC OF CONGO

Kasai

DEMOCRATIC REPUBLIC OF THE CONGO

RWANDA

Kagera

BURUNDI

Kwango

Congo

Lualaba

SO...

Pool

Congo

★ **Kinshasa**

Kinshasa City

● Kasangulu

Bas-Congo

Zambezi

ZAMBIA

Kafue

MOZAMBIQUE

LA

0   120   240
Km
GCS: WGS 84
Datum: WGS 84

Interventions of the Eco-DRR
project in the Lukaya River Basin,
southwest of the city of Kinshasa
in the Democratic Republic of
the Congo.
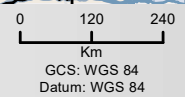
Sources:
Natural Earth

The boundaries and names shown and the designations used on this map do not imply official endorsement by the United Nations. UNEP 2013.

LOCAL CONTEXT

The Lukaya River basin is located southwest of Kinshasa, the capital, and is a vital source of drinking water for approximately 400,000 of its 10 million inhabitants. With a surface area of 355 km², the river basin straddles two provinces: the Central Kongo Province in the upstream (south) and Kinshasa Province in the downstream section (north). The basin is a sub-catchment of the N'Djili River, which flows into the Congo River. From its source near the village of Ntampa, the Lukaya River traverses nearly 55 kilometres to its confluence with N'Djili River.

Precipitation in the Lukaya basin (1400 mm/year on average), as in the rest of western DRC, shows strong seasonality. The wet season lasts from October to May; the dry season is from June to September, during which the basin hardly receives any precipitation.

The catchment is divided into two zones: an upstream section centred on the town of Kasangulu (**MAP 2**), which is mainly rural, and a downstream zone located around the densely urbanized Kinshasa neighbourhood of Kimwenza, where a large part of the anthropogenic pressure is concentrated. The national road (RN1) which traverses the western ridge of the basin connects the Central Kongo Province to the capital.

Almost half (46%) of the area of the basin is being used for agriculture (**FIGURE 1**). Primary and secondary forest together make up 26% of the land cover, while grassland and woodland savanna cover another 26%. At least 2% of the land cover is now completely bare of vegetation as a result of deforestation. The downstream area of the watershed is undergoing rapid and unplanned urbanization, as the capital expands horizontally.

FIGURE 1. Land cover distribution in the Lukaya River Basin based on analysis of the Landsat 8 image
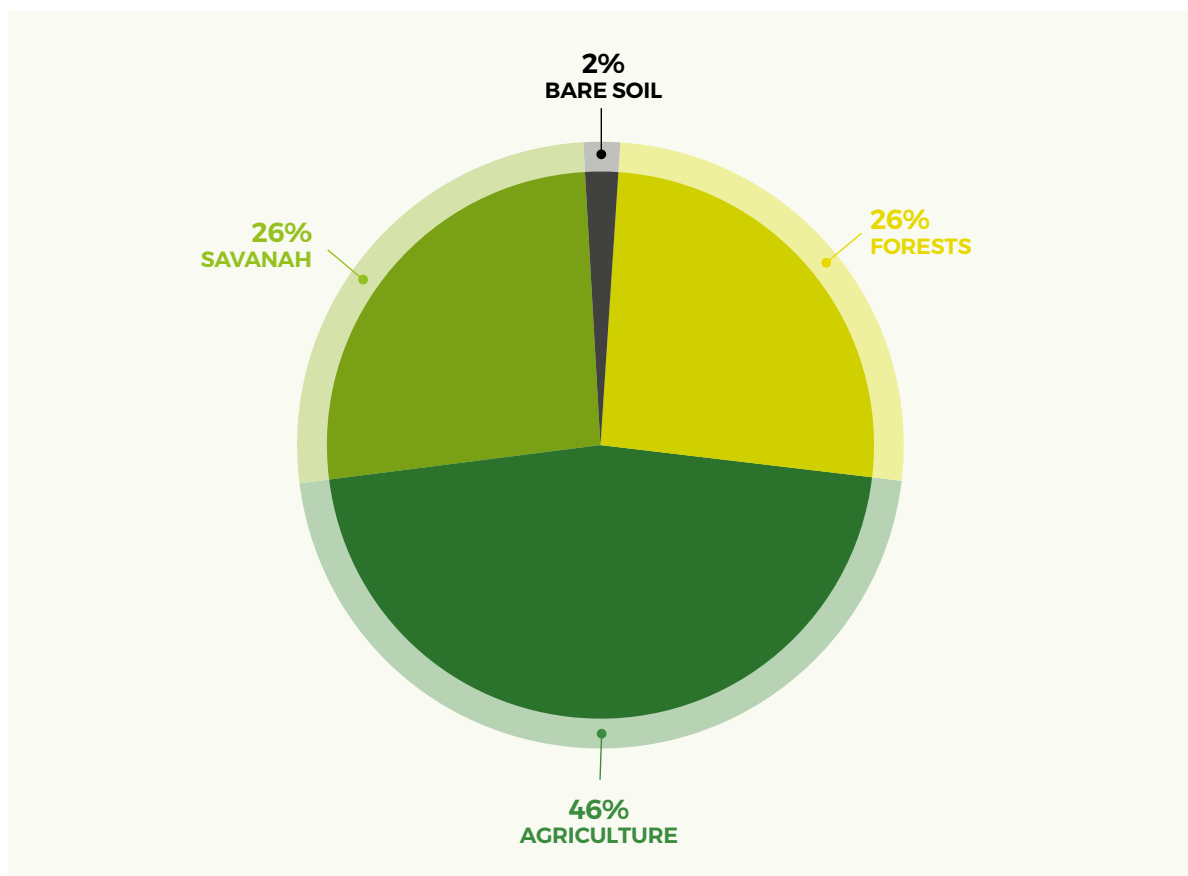
2%
BARE SOIL

26%
SAVANAH

26%
FORESTS

46%
AGRICULTURE

to Kinshasa

Kinshasa

Kimwenza

REGIDESO
Water Treatment Plant

Kasangulu

OBSCOM 2015

0   5

Km

Ntampa
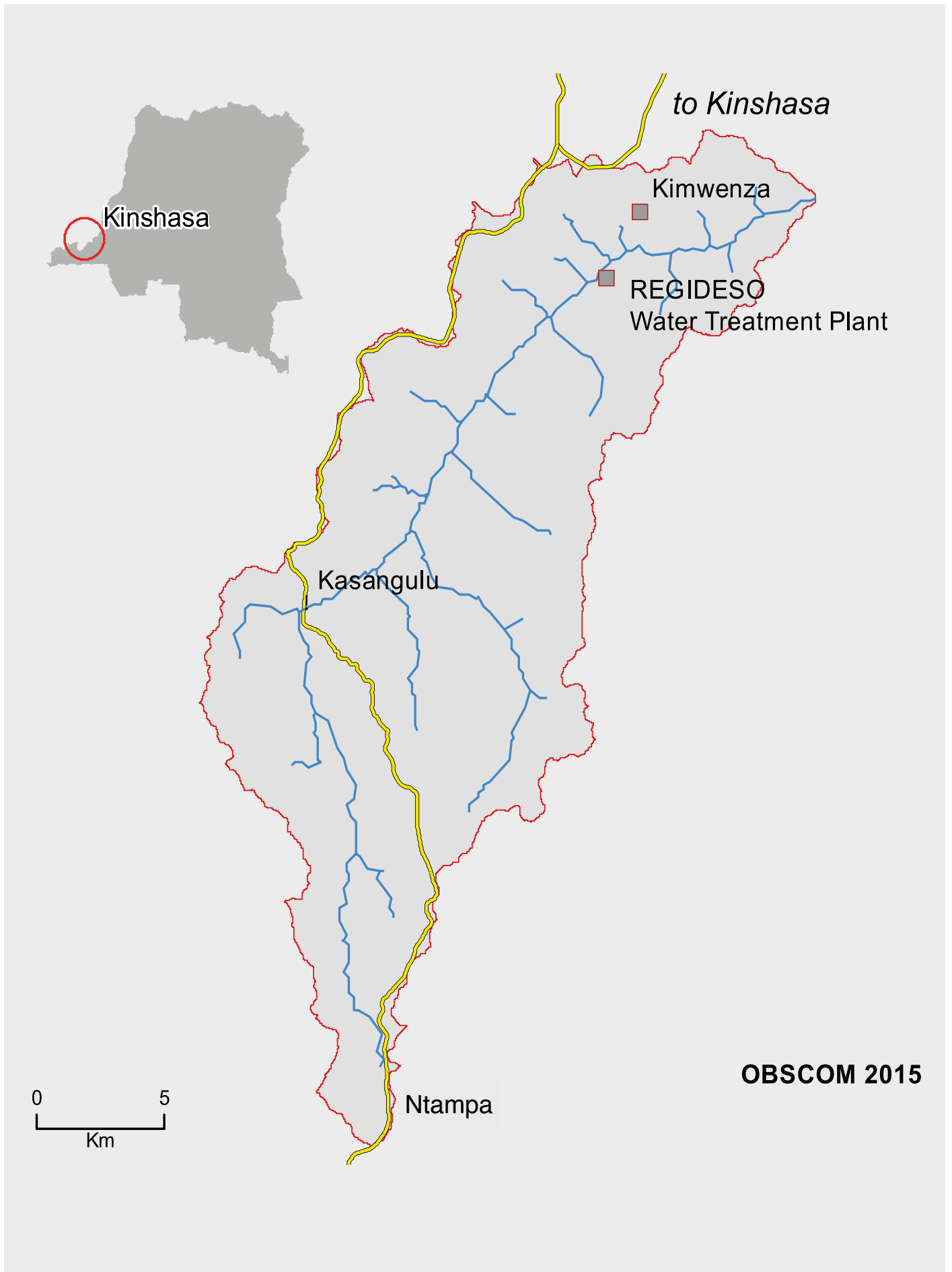
MAP 3. Land use and land cover map based on satellite image (LANDSAT 8; 28 July 2013). The most significant land use types observed in the Lukaya River basin were (secondary) forest, agriculture, savannah and bare soils, with some urban land close to Kinshasa in the north.[3]

LULC from LANDSAT image (2013)

- Unclassified
- Water
- Forest
- Marshland
- Agriculture
- Urban
- Savanna
- Bare soil

Sources:
RGC, Esri, OBSCOM, SRTM

GCS: WGS 84
Datum: WGS 84

The boundaries and names shown and the designations used on this map do not imply official endorsement by the United Nations. UNEP 2013.
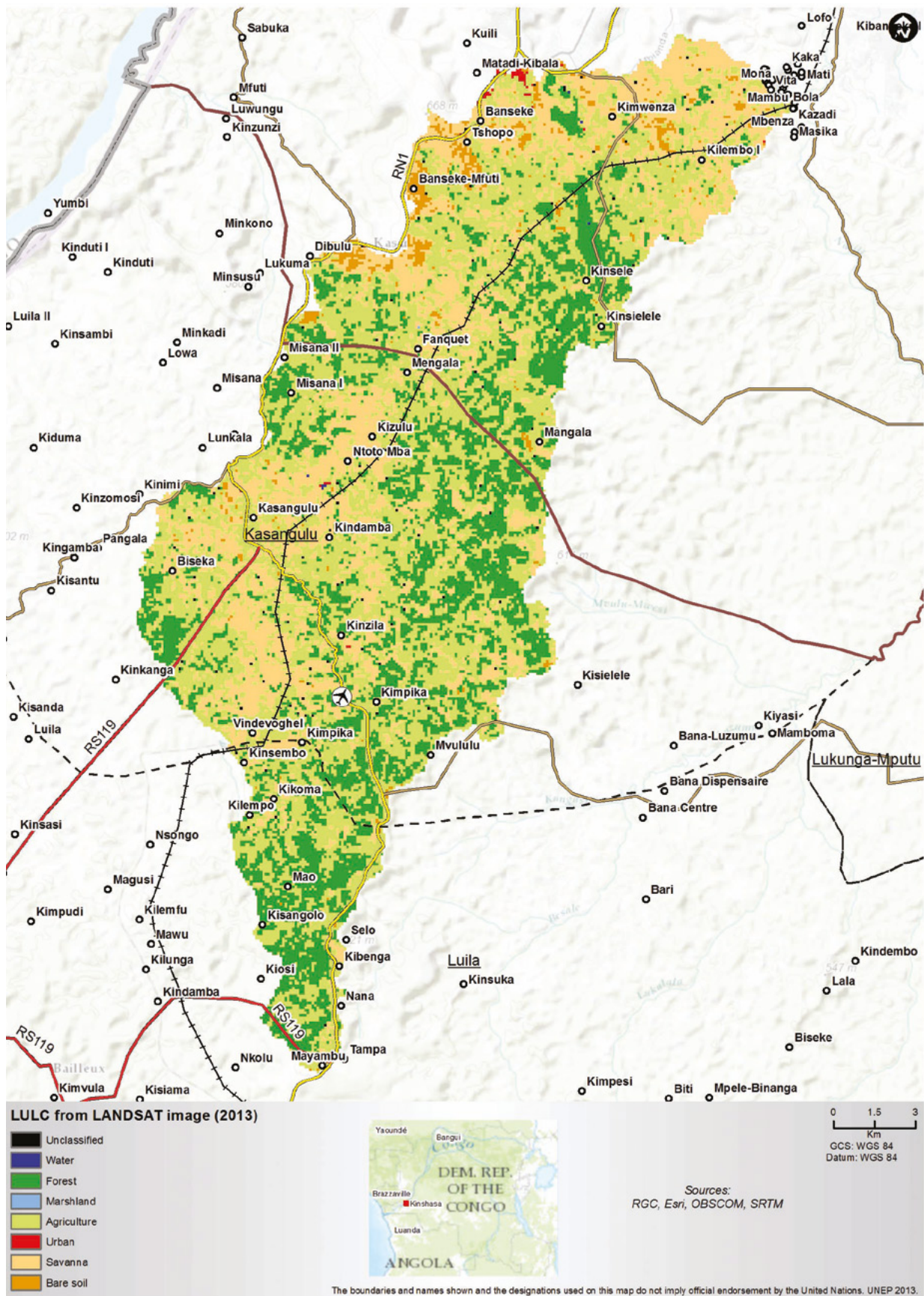
[3] A series of thematic maps were developed in order to provide information on physical and hydrological characteristics of the watershed (geology, topography, drainage network, etc.). A land use/land cover (LULC) map was developed based on a Landsat 8 image acquired on 28 July 2013. The original map of 30-meter resolution was filtered and downscaled to 90 m per pixel. LULC was classified through supervised classification (Maximum Likelihood) using ENVI 4.6.1 software.

The upper catchment of the Lukaya Basin is mainly rural

In the peri-urban lower catchment houses are built on deforested slopes

Charcoal production is an important source of livelihoods in the Lukaya

In the rural upper catchment, such as Kasangulu and Ntampa, rain-fed subsistence agriculture (often as slash and burn) is the principal activity for 85% of the population, with both men (46.1%) and women (39.5%) involved. Field cultivation is at a very localized scale, which takes place mostly around houses and includes annual crops (e.g. cassava, corn), fruit trees (e.g. banana, avocado, mango, mangosteen) and horticulture (i.e. small scale gardening of eggplant, red pepper, tomato, celery etc.). Poultry, goats, pigs and sheep constitute the main livestock. In Kimwenza and other peri-urban (i.e. a hybrid space with both urban and rural characteristics) areas of the lower catchment, artisanal quarrying and industrial extraction of sand and stone are some of the main activities, alongside agriculture, horticulture and livestock keeping.

Other livelihood activities include tree cutting and charcoal production, which is a major driver of deforestation, given that the basin is a major supplier of charcoal to meet the energy needs of Kinshasa.

Other activities directly linked to natural resources include production of palm wine (a local artisanal drink), fishing and bee-keeping. Brick production is also common across the watershed and is partly responsible for the high demand for fuelwood. A number of large-scale timber concessions also exist, whose deforestation footprint is visible on the hills.

Tourism is another source of revenue, particularly in the lower watershed, and gandas (local bars and restaurants) along the river attract many visitors from Kinshasa over weekends and holidays. The Lola ya Bonobo, a sanctuary for bonobos (an endangered great ape species), and the Lac Ma Vallée are important tourist attractions for Kinshasa residents.

The challenge of land tenure is not limited to urbanizing areas of the lower watershed. A detailed socio-economic survey in the upper watershed found that 23% of the population of Kasangulu is landless due to sale of land to concessioners, eviction and conflicts over land tenure.[iii]

Click above (or visit http://bit.ly/25tttTD) to view a video of Lola ya Bonobo sanctuary.

2 MAIN HAZARDS, DEVELOPMENT TRENDS & CHALLENGES IN THE LUKAYA RIVER BASIN

Slash and burn agriculture
in the Lukaya River Basin

Community and national baseline assessments, including 3D land-use and risk mapping (described further in **SECTION 3**) and multi-stakeholder consultations, provided the primary basis for obtaining information on the major development trends and challenges related to land use, ecosystem degradation and disaster risk in the Lukaya River basin. The baseline assessments also served as a basis for project design and defining the key components of the Eco-DRR intervention in DRC. Moreover, the project drew upon UNEP's assessments conducted in 2011: **"The Democratic Republic of the Congo: Post-Conflict Environmental Assessment"**[IV] and **"Water issues in the Democratic Republic of Congo: Challenges and Opportunities".**[V]

The Lukaya River Basin faces many challenges. Unplanned and rapid urbanization, slash and burn agriculture, quarrying, charcoal production and horticulture along the river have resulted in deforestation, excessive sedimentation, and high incidence of flooding. Heavy sedimentation in the Lukaya River reduces water quality, blocks river flow, affects local fisheries and increases water production costs at the water treatment plant in Kimwenza, which is one of the four centers supplying drinking water to Kinshasa.

Water resource management in Lukaya - and in the country - remains a challenge. Many of the problems stem from unplanned and uncoordinated land use across the basin. Without a common land use plan for the Lukaya River basin, reconciling the needs of diverse resource users is a difficult task. There is no water- and land-use management plan at the provincial level much less at the catchment-scale. In addition, regulating land and water resources across the entire basin is beyond the capacity or jurisdiction of local government authorities, i.e. territorial administrators, sector managers or village chiefs.[4] This further makes it difficult to tackle disaster and climate risks linked to water related hazards. As part of a regional policy of Central African states, the Government of DRC has initiated a national transition towards IWRM, which provides an opportunity to integrate disaster and climate risks in water catchment management.

[4] *Administrative structures in the DRC are divided into territories, sectors, collection of villages, and villages or chiefdoms, which are headed by village chiefs.*

Slash and burn agriculture

High level of sedimentation in the Lukaya River

Children carrying water from the source of the Lukaya River in Ntampa. Like many areas in DRC, access to drinking water is a significant challenge to many households in the Basin

2.1. ECOSYSTEM DEGRADATION INCREASES GULLY EROSION AND FLOOD RISK

The Lukaya River basin has been subject to extensive deforestation. Most of the remaining forested land consists of secondary forest, with the exception of a few patches of relatively protected primary forests, such as the Lola ya Bonobo sanctuary.

Widespread deforestation in the Lukaya River basin has exposed the soil, which is naturally prone to erosion because of its sandy composition. Extensive soil erosion and formation of gullies are visible on a large number of the slopes on the steep northwestern water divide of the catchment, particularly along the national road (RN1) and in peri-urban areas. Severe erosion results in silting of water sources, river bank erosion, slope destabilization and landslides, which can block stream and river flows. When blocked rivers are then breached, they may cause water surges downstream, thus increasing flood risk. As gullies expand, they threaten people and community assets by destabilizing slopes and damaging buildings.

Rainfall, particularly torrential downpours during the rainy season, washes soil down the slopes and into the valleys where they end up in the Lukaya River and its tributaries, giving them a brownish color. Excessive sedimentation raises the river bed and blocks the few culverts (many of which have sub-standard designs), thus also increasing the risk of flooding. Floods and the lack of adequate drainage systems in turn affect agricultural production, due to overflow and facilitate the spread of water-borne diseases.

According to local residents, flooding has become more frequent and has had serious impacts on the population. In December 2012, a flood in Kasangulu, located in the mid-watershed, took the lives of two people and affected another 222 residents. The main bridge of the town and many houses were damaged, severely restricting movement and obligating the Government to distribute food relief to hundreds of affected households.

As gullies expand, they threaten people and community assets by destabilizing slopes and damaging buildings

Bridge damaged by 2012 flooding in Kasangulu

**Click above (or visit http://bit.ly/1THgbLR) to view an interview with Mr. Clément Nzobasina,
a resident affected by the 2012 flooding in Kasangulu.**

Urban sprawl further exacerbates flood risk. The majority of the urban population (75% nationally) live in informal settlements and slums. Population growth and rural migration to Kinshasa are driving people to build houses and cultivate on very steep slopes (<60 degrees) or on the edge of the plateau. Soil conservation techniques are rarely applied in farming. Therefore, farming on slopes quickly removes the top soil which may result in soil creep and land slips. Once the land is no longer suitable for cultivation, farmers tend to sell their parcels, which are then used for housing construction. Encroachment of urban settlements on steep slopes therefore often takes place without proper drainage systems or the restoration of vegetation, which then contribute to increased soil erosion and flooding.

2.2. SEDIMENT POLLUTION INCREASES THE COSTS OF DRINKING WATER PRODUCTION

The Lukaya River basin and other watersheds surrounding Kinshasa are a key source of drinking water to the capital. However, the excessive sediment load in rivers, including Lukaya, has reduced water quality and raised costs of drinking water production. There are two water treatment plants in the Lukaya River basin, located in Kasangulu and Kimwenza. The plant in Kasangulu is small, with a capacity of 2,400m³/day and supplies water to 1,644 residents in the town of Kasangulu. On the other hand, the plant in Kimwenza has a maximal capacity of 36,000 m³ per day and is one of four main sources of drinking water to Kinshasa. Both water treatment plants are operated by REGIDESO, the public utility company in charge of production and supply of water in the country's urban centers.

Although the water treatment plants are designed to filter a certain amount of sedimentation (up to 450 NTU), the excessively high sediment load in the Lukaya River (often as high as 1,600 NTU) forces occasional shut downs of the Kimwenza plant. Consequently, larger quantities of imported chemicals (aluminum sulfate, lime) need to be used to precipitate the excess sediment from the water. In addition, surplus sediment is manually removed from the intake point, feeder channels and sedimentation ponds. High water turbidity means higher concentration of bacteria, which requires more chemical treatment with chlorine. The net result of elevated river sedimentation is higher costs of drinking water production.

Intake point of the REGIDESO water treatment plant in Kimwenza.
High level of sedimentation in the Lukaya River raises water production costs

2.3. NATIONAL POLICY CONTEXT ON DISASTER RISK REDUCTION AND WATER RESOURCES MANAGEMENT

Disaster management in DRC has been primarily focused on response and recovery, with less attention to prevention. Whereas a number of plans and strategies exist that can contribute to Disaster Risk Reduction (DRR),[5] the DRC does not have national policies or legislations that specifically address DRR. In addition, there is insufficient capacity within the Government to effectively undertake disaster prevention and management.[vi]

Lack of a coherent national strategy on DRR has impeded coordination among National Government institutions. The institutional mandate for DRR remains unclear and is shared between the Ministry of Interior and the Ministry of Social Affairs, Humanitarian Action and National Solidarity. Furthermore, collaboration with the Ministry of Environment, Nature Conservation and Sustainable Development (MECNDD) and other environmental actors on DRR-related concerns has been limited; therefore, there is less attention on addressing environment, climate and disaster linkages and mainstreaming sustainable ecosystem management in national disaster management and prevention strategies.

Climate change is expected to further exacerbate disaster risks and result in high impacts in DRC. Extreme events expected under current climate change scenarios will mean dry seasons alternating with sudden precipitation, which are likely to affect soil structure, fertility and quality and thus the ability to sustain sufficient crops for the country's population, whose majority depends on rain-fed small-scale agriculture for subsistence.[vii] Expected changes in rainfall variability patterns will increase food insecurity and exacerbate flood and drought risks in specific regions in the country. Hence, enhancing pastoral and agricultural production capacity has been identified as a key national adaptation priority.[viii] However, these issues are not sufficiently addressed in national policies on water resource management.

In line with the DRC's decentralization policy, water resources are to be managed at the provincial level and by local institutions. However, there is often a mis-match between administrative divisions and geographic boundaries of watersheds, which necessitates coordination among local authorities in the same basin to manage shared water resources. In addition, the country is emerging from a long period of protracted conflict, which has adversely impacted state institutions for many years. The absence of river basin authorities in the DRC has hindered the sustainable management and governance of water resources, which contribute to ecosystem degradation and hence increased vulnerability to gully erosion, flood risks and climate change impacts.

The DRC contributed to the formulation of a regional water policy by the Economic Community of Central African States (ECCAS), which was officially adopted in 2009. To implement the regional water policy, ECCAS with support from the African Development Bank developed a Regional Action Plan on IWRM (PARGIRE) (2009- 2025) according to which each ECCAS member country must develop its own guidance documents for its national transition to IWRM: inventory, national policy roadmap, etc. Although not explicitly stated, the regional IWRM approach is also an opportunity to address water-related disaster and climate risks in national policies, plans and legislations.

As part of this process, in November 2011, the Government of the DRC, led by the Ministry of Environment, Nature Conservation and Sustainable Development (MECNDD), initiated a national assessment of water resources management in the DRC. In 2012, the DRC adopted "la feuille de route du secteur de l'eau 2011-2020" (i.e. Water Sector Roadmap), a document prepared by the National Action Committee for Water and Sanitation (CNAEA). In addition three reports on the technical, legal and institutional aspects, as well as on the economic and financial aspects of water resource management were developed and validated in 2013. A new Division on the Implementation of Basin Management Units and Sub-basins, under MECNDD, was also established in 2013.

Finally, in January 2016, the Government of the DRC enacted a national Water Law, which is based on IWRM principles and the management of water resources at the river basin scale. While the law undoubtedly marks a major step in the DRC's reform of water resource management, there remain a number of inconsistencies and institutional matters which need to be clarified and which could potentially be addressed under the planned National Water Policy. In this regard, disaster and climate risks related to water resources could also be addressed by the National Water Policy (discussed further in **SECTION 3.4**).

[5] *For instance The Poverty Reduction Strategy Paper (PRSP) (2011-2015) and The National Strategy for Social Protection of Vulnerable Groups (developed in 2008).*

3

MAIN COMPONENTS OF THE ECO-DRR PROJECT IN DRC

Congo River

The Eco-DRR project implemented in the Lukaya River basin took into account the key development challenges, as described in **SECTION 2**. The project was cognizant of the inter-linkages between rapid urbanization, deforestation, increased gully erosion and flood risks, and the subsequent impacts on livelihoods and water supply. At the same time, it considered DRC's national policy environment, particularly in view of ongoing reforms in the water resources sector, and the opportunities for promoting Eco-DRR through IWRM implementation.

Building on UNEP's first practical experience of IWRM in the country, the Eco-DRR project in DRC targeted disaster and climate risk reduction objectives as an integral part of the IWRM process (**FIGURE 2**). The widely accepted definition of IWRM, by the Global Water Partnership states:[xi]

> " IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. "

FIGURE 2. Eco-DRR approach in the Lukaya River Basin.

DEMOCRATIC REPUBLIC OF THE CONGO (DRC)
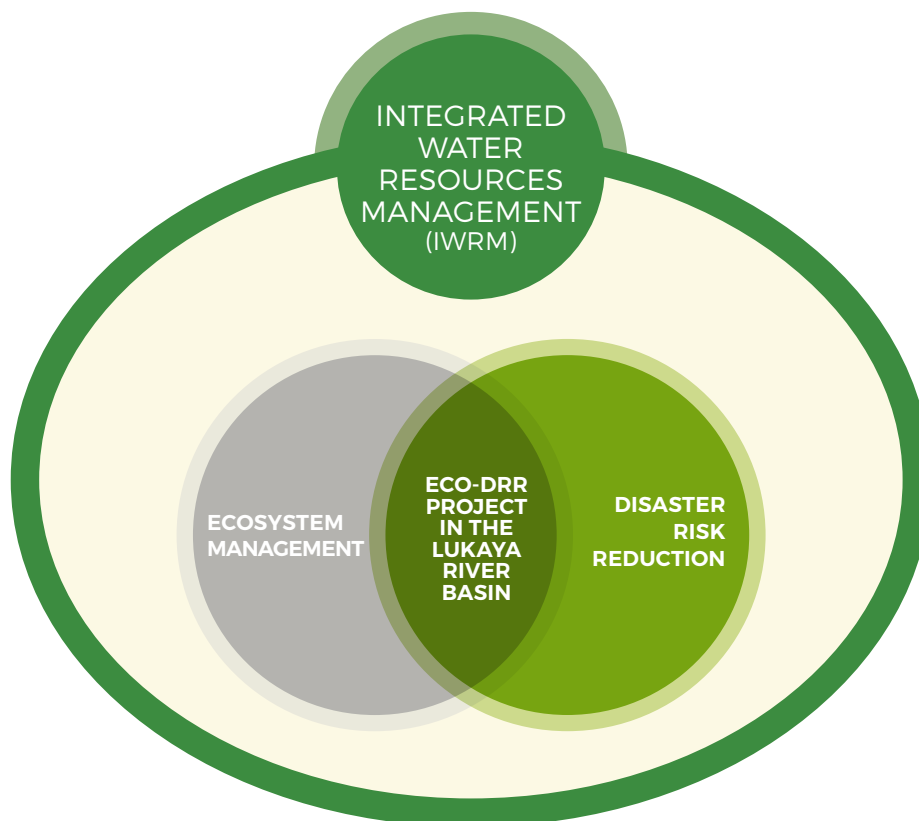
THE PROJECT HAD FOUR MAIN COMPONENTS:

1
MAINSTREAM ECO-DRR IN THE DEVELOPMENT OF AN IWRM ACTION PLAN FOR THE LUKAYA RIVER BASIN

2
UNDERTAKE FIELD INTERVENTIONS, INCLUDING REFORESTATION, AGROFORESTRY AND GULLY EROSION CONTROL THROUGH BIOENGINEERING TECHNIQUES

3
DEVELOP LOCAL AND NATIONAL CAPACITIES FOR IMPLEMENTING ECO-DRR THROUGH IWRM

4
SUPPORT NATIONAL ADVOCACY ON ECO-DRR THROUGH IWRM

3.1. MAINSTREAMING ECO-DRR IN THE IWRM ACTION PLAN

The developmental challenges found in the Lukaya River Basin are very much representative of trends found in peri-urban areas in DRC. This small catchment must respond to multiple, often conflicting water-use and land-use needs between the local residents and settlers downstream and upstream.

Recognizing the importance of water resources for long-term sustainable development within the Lukaya basin, the project aimed to mainstream Eco-DRR as part of broader efforts to develop a comprehensive IWRM Action Plan. The Eco-DRR project was implemented in conjunction with the UNDA-funded IWRM project, in order to establish a risk-informed and sustainable water resource management framework for the Lukaya basin. In doing so, one of the principal priorities of the project was to reinforce the organizational capacity of the Association of the Users of the Lukaya River Basin (AUBR/L), an existing but still young water users' association (created in April 2010), as a primary stakeholder who would lead the development and implementation of the IWRM Action Plan.

Indeed, one of the main achievements of the AUBR/L is the development of the Action Plan (2016-2018), which provides a roadmap for water resource management in the Lukaya watershed. Endorsed by the AUBR/L and the National Government, the Action Plan serves as the primary reference document for the sustainable development of Lukaya. The Plan outlines a series of priority actions under four main pillars: water, environment, land use planning and governance. An integral component of the Action Plan is promoting sustainable ecosystem management approaches for disaster risk reduction, within the overarching framework of IWRM. Eco-DRR activities, such as reforestation and agroforestry as well as monitoring of soil erosion, hydro-meteorological and flood risk monitoring, are included in the Action Plan. The plan will be reviewed at the mid-term and end points in view of developing a follow up plan.

The entire process of IWRM action planning was intensive and lengthy, taking almost one year for the AUBR/L to elaborate the first draft of the Action Plan. An international expert on IWRM working with UNEP provided technical guidance and support throughout the process. Various technical experts from different ministries (Environment, Agriculture, Land use, Land Tenure) as well as NGOs (CADIM and Association

pour le Développement Intégral en Milieu Rural/ADIR), universities and research centers (University of Kinshasa, CGEA/CREN-K, ERAIFT) and the International Commission for the Congo Ubangi Sangha Basin, have reviewed the IWRM Action Plan. The Plan has been finalized and the AUBR/L is responsible for its implementation by contacting, educating, encouraging, assisting and building ownership among water users. A formal presentation of the Action Plan by the Government, AUBR/L and UNEP to international development partners in DRC is scheduled for June 2016. The total cost of implementation of the Action Plan is estimated at approximately USD 3.7 million. The IWRM Action Plan will be made available online after June 2016.[6]

REINFORCING THE ASSOCIATION OF THE USERS OF THE LUKAYA RIVER BASIN (AUBR/L)

As a first priority, the project supported registration of the AUBR/L with the MECNDD in order to give it a formal legal identity. Through the AUBR/L, a clear coordination mechanism was established among the upper catchment and lower catchment communities, which were accompanied by a number of capacity building activities (discussed also in **SECTION 3.3**).[7] Participants worked together to identify the different users or stakeholders within the Lukaya River basin and the ecosystem services [8] that benefit different activities, such as water production, market gardeners, industrial quarries, and bee-keeping. This resulted in the establishment of an effective IWRM structure for stakeholder coordination and participation, which was tailored to the Lukaya context.

AUBR/L was restructured to constitute the following:

1 a coordination unit, which oversees the activities, ensures that all stakeholders have a voice and guarantees continuity of the participatory governance over time;

2 a river committee, which includes all users of the basin, and

3 a technical committee that provides technical support and assistance (**FIGURE 3**, page 37).

Meeting of the AUBR/L

In addition, two sub-committees were set up: the upstream sub-committee includes users from Ntampa to Kingantoko through the city of Kasangulu, and the downstream sub-committee consists mainly of users of neighborhoods of Kimwenza, Matadi Kibala and Kilambu N'djili. Each of these sub-committees comprise representatives of various member organizations of the association and sectors of activity.

The sub-committees operate according to "river contracts". The users themselves defined the organizational structure and functional roles of the committees. Local authorities are also members of the two sub-committees.

Two offices were also established - each in a different section of the basin - to ensure the effective operation of the sub-committees. Within AUBR/L, river users or stakeholders, such as residents and business owners, are grouped based on their sector of activities, and maintain their existing structures such as the Union of Horticulturalists Groups in Kimwenza (UGMK), the Fish Farm in Kasangulu, Lola ya Bonobo (bonobo sanctuary), Sous l'Arbre (Under the Tree) a non-government organization (NGO), Centre de Broyage d'Afrique (SBA quarry), the Association of Working Women for Development (AFOD), health centers, schools and drinking water production sites of REGIDESO in Kimwenza and Kasangulu, as well as village leaders in Ntampa, Kingantoko, Mafumbu and Ndjili Kilambu. A stronger collaboration between the AUBR/L and the Water Resource Directorate of MECNDD was also supported.

6 See **www.unep.org/drcongo/**
7 For more information on AUBR/L see **www.aubrl-cd.org**
8 *Ecosystem services refer to the benefits that people gain from nature. These include provisional services (e.g. food, water), regulating services (e.g. flood mitigation by wetlands), supporting services (e.g. nutrient cycles), and cultural services (e.g. aesthetic or spiritual value of nature).*

> " I AM PROUD OF THE RIVER USERS' ASSOCIATION OF LUKAYA. IT BRINGS US - WE THE PEOPLE OF NDJILI KILAMBU VILLAGE - TOGETHER WITH THE PEOPLE OF OTHER COMMUNES TO RECONCILE ISSUES OF UTMOST IMPORTANCE."
>
> **MADAM HONORINE KIMPEYALA - VILLAGE CHIEF IN NDJILI KILAMBU**

FIGURE 3. Organigram of the Association of the Users of the Lukaya River Basin (AUBR/L)

COORDINATION

AUBR/L COORDINATION CELL

STAKEHOLDER PARTICIPATION

LUKAYA RIVER SUB-BASIN COMMITTEE (PLENARY ASSEMBLY) MEET ONCE A YEAR

UPSTREAM RIVER USERS COMMITTEE
Meets once per trimester

DOWNSTREAM RIVER USERS COMMITTEE
Meets once per trimester

LUKAYA RIVER TECHNICAL SUPPORT AND CONTRACT ENDORSEMENT COMMITTEE
meets once per trimester (coordinated by MECNDD/DRE)

UPSTREAM FOCAL POINT
per section of activities and link with concerned users
(one person per section)

DOWNSTREAM FOCAL POINT
per section of activities and link with concerned users
(one person per section)

1. Market gardeners
2. Quarrying
3. Traditional leaders
4. Sacred aspects
5. Beekeepers
6. Farmers
7. Other

1. Land managers
2. Tourism
3. Garden farmers
4. Nature conservation
5. Regideso
6. Fish farmers
7. Livestock breeders
8. Other

LINKING UPSTREAM AND DOWNSTREAM COMMUNITIES AND RECOGNIZING DISASTER RISKS

Development of the IWRM Action Plan emphasized the importance of linking upstream and downstream communities and strengthening their knowledge of the geographic and socio-economic conditions within their shared river basin. Three-dimensional (3D) participatory mapping was used to map hazards, land use types, natural resources and identify major environmental problems and areas at risk in the basin, through a multi-stakeholder, participatory approach.

The Network for Natural Resources (RRN) was the leading partner organization in the development of the 3D maps. The process was also aimed at strengthening AUBR/L as a coordinating and decision-making body for IWRM, by involving different river users throughout the mapping exercise. The 3D mapping further helped to explicitly link natural hazards, climate and disaster

risk as part of river users' analysis of the river basin and their water resource management challenges (see **BOX 3**).

Through several multi-stakeholder workshops, which took place with upstream and downstream river users, 3D models were constructed depicting different sections of the Lukaya River basin. The visual representation of the basin, which was made to scale, provided a physical framework that facilitates dialogue between various river users.

The process enabled participants to identify different resource uses and their upstream and downstream effects and to collectively map natural resources, land use, natural hazards and disaster events, as well as environmental and climatic changes over time. As a result, participants gained appreciation of the basin as a shared landscape and identified common priorities for sustainable watershed management, which also contributes to climate and disaster resilience.

BOX 3. PARTICIPATORY 3D MAPPING IN LUKAYA

Participatory 3-dimensional mapping (P3DM) can be an excellent tool for promoting risk-informed, ecosystem-based watershed management. The P3DM method facilitates the integration of local spatial knowledge with topographic data through the participation of many stakeholders and the use of geographic information systems (GIS).

Three separate 3D models were built, which subsequently were put together into one 3D model of the entire Lukaya River basin. The first 3D map (2.66 x 1.60 m) represented the downstream area centered around Kimwenza – between Mafumba Kilambu and N'Djili. The second map (2.13 x 1.67 m) represented the area around Kasangulu. The third map (2.13 x 1.67 m) depicted the entire basin and was derived and refined from the two initial maps. Mapping was undertaken in two workshops convened in Kimwenza and Kasangulu in May 2013, each workshop lasting for one week and involving around 60 participants, including local residents, MECNDD staff, civil society organizations and private businesses.

Model construction involved a number of steps. First, an expert 3D modeler developed base maps using a topographic layer (i.e. a digital elevation model or DEM) scaled and geo-referenced to an appropriate level. During the first meeting, participants developed the legend to be used for the mapping exercise (what information to add, symbols, colors etc.). The second step was to assemble the 3D model using layers of bonded foam. Participants cut the foam layers following contour lines of each elevation layer. Once the topography of the area was developed, participants identified land use types, hazards, disaster events and other important elements of the landscape on the map, based on their local knowledge. Once the 3D model was completed, it was scanned and georeferenced to transfer the information into two-dimensional digital layers (GIS files), which could be used to extract thematic maps.

PARTICIPATORY 3D MODELLING ALLOWED USERS TO:

- Visualize interactions between water users in the Lukaya River basin and their upstream and downstream impacts, and the emerging issues;

- Perceive the need for a systemic and integrated management of ecosystems in the watershed;

- Situate themselves in the watershed and better understand the principles of sustainable management of natural resources;

- Better understand the concepts of disaster risk reduction such as natural hazards and areas at risk;

- Engage in multi-stakeholder dialogue involving all key users to develop a sustainable and risk-informed land use plan for the entire river basin: Government agencies, communities, civil society organizations, and the private sector.

The 3D model is intended to be a dynamic tool, which could be altered over time. The 3D model of the downstream section of the watershed is now exhibited at the Lola ya Bonobo Sanctuary, while the model of the upstream section is displayed at the Kasangulu Territorial Administration Office. The public exhibition of the 3D models has also increased the visibility of the AUBR/L within the communities.

FIGURE 4. 3D map of the lower watershed produced through participatory mapping and transcribed into a two-dimensional map.

ESTABLISHING LOCAL RISK MONITORING SYSTEMS

An integral component of mainstreaming Eco-DRR in the IWRM Action Plan was the establishment of baselines and data gathering to inform IWRM planning, which included soil erosion and hydro-meteorological monitoring and flood risk modelling.

Monitoring soil loss

As discussed in previous sections, the extremely high level of soil erosion in the Lukaya River basin is contributing to the increased risk of flooding in low-lying areas. However, as is the case in most of the country, very little information has been collected on the extent and speed of soil erosion in the basin. The project therefore pilot tested a soil erosion monitoring methodology using pins in Mafumba, a sub-watershed within the Lukaya River basin, taking into account its small size for demonstration purposes. In the process, the project developed local capacity within AUBR/L and the National Government to implement the methodology and raise their appreciation of the importance of establishing baseline data for decision-making.

Pins (**FIGURE 5**) were placed directly on the side of gullies and along the river bank to calculate how fast the soil was being washed away. Pins were also installed downstream of the project's field intervention sites to monitor the effectiveness of vetiver, acacia plantations and the agroforestry system in reducing soil erosion (discussed further in **SECTION 3.2**).

FIGURE 5. Schematic view of an erosion pin planted in the soil. A simple, durable model of soil erosion pins made out of wood and iron was constructed locally.
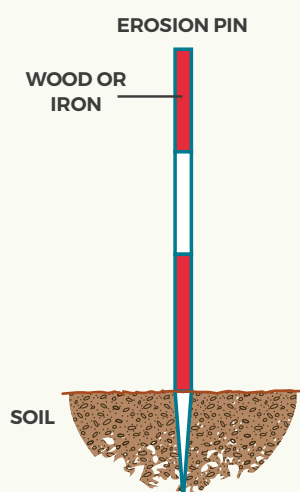
With erosion after rainfall, the pins would be monitored as they are washed down the slope. Information on the distance between the original and final location of the pins, the amount of rainfall and other factors related to topography was used to calculate the erodibility of the soil and the total amount of eroded sediment.

The methodology was presented to the village leaders of Mafumba, through a number of meetings to build trust and prevent vandalism. In addition, three groups within the community were created to implement the activity:

1 a group of men and women amongst AUBR/L members, who were trained on soil erosion data collection;

2 a group of stakeholders directly using land parcels, where erosion pins were installed;

3 a group of young community members. The groups remained in close contact with the AUBR/L and agreed to inform the AUBR/L once the pins were washed away. All group members were trained to install and monitor the pins.

Based on field measurements and monitoring from 02 December 2014 to 02 April 2015 in Mafumba, the initial study quantified different rates of erosion (i.e. the average distance of pin movement over this period) and provided an estimate of eroded sediments (**TABLE 1**). An average loss of 17.6 tons per hectare (t*ha-1) of sediment loss over four months was estimated in Mafumba Sub-watershed. Four types of erosion were identified as the most important sources of sedimentation in the Lukaya watershed: sheet erosion,[9] gully erosion, landslides and river bank erosion. Forest and shrubland showed the lowest erosion rate compared to degraded land and bare soils. Such information can be used to validate the soil erosion modelling undertaken through InVEST software (see **BOX 4**). While at least one year of data is required to calculate a realistic approximation of soil erodibility, the results provided an initial indication of the extremely high soil loss in the Mafumba sub-watershed.

[9] *Sheet erosion refers to the removal of a more or less even layer of soil particles by rainfall and continuous movement of water over an extensive area*

TABLE 1. Initial results of soil erosion monitoring

SITE	AVERAGE DISTANCE OF PIN FROM INITIAL LOCATION	AVERAGE SEDIMENT LOSS*	AVERAGE TOTAL SEDIMENT LOSS **
Upper section of sub-watershed	30m	12.5 t	**17.562 t**
Mid section	10m	5 t	
Lower section	0.60m	0.62	

** Calculated based on the standard formula: Total volume of sediment lost = surface area x distance of pin from initial location. ** Sum of three sections.*

Initial data was presented to the AUBR/L and local residents to demonstrate rapid rates of erosion, which highlighted the urgency of taking action and gained local support for vetiver planting (discussed in **SECTION 3.2**). This soil erosion method is valuable in developing other studies throughout the Lukaya watershed, where surveillance data and systematic field-based scientific evidence is lacking. Use of readily available materials for the erosion pins makes it feasible to produce and maintain them locally. The information could be used to assess the effectiveness of proposed soil erosion measures, which takes into account the geomorphological processes at the watershed scale. However, more long-term data collection is needed to inform future decisions on tackling soil erosion.

Installation of erosion pins in Mafumba. A total of 110 erosion pins were installed and georeferenced.

BOX 4. MODELLING SOIL EROSION POTENTIAL USING *InVEST* SEDIMENT RETENTION MODEL

InVEST (Integrated Valuation of Environmental Services and Tradeoffs) Sediment Retention model (version 3.0.0) was applied to examine soil erosion and sedimentation potential at a sub-watershed scale in Lukaya. Developed by the Natural Capital Project, InVEST is a set of open source GIS models, which are scenario-driven and can provide evidence-based information about how changes in ecosystems and land use influence the flow of ecosystem services (or natural capital) to people.; It includes models that evaluate regulating services of ecosystems, which are linked to reducing disaster risk (e.g. coastal protection, sediment retention). The relatively low data requirements makes InVEST models applicable to data-poor countries such as the DRC.[xii]

The InVEST Sediment Retention Model estimates the capacity of a land parcel to retain sediment by using information on soil types, slope, land management practices and the influence of vegetation on retaining sediment. Outputs are in terms of the annual average of total sediment load (in tons) that is exported to streams from the watershed.[10] InVEST was tested in the DRC to help inform the selection of project interventions. Data was collected through a combination of remote sensing and field measurements in the watershed.

OBJECTIVE 1:

TO IDENTIFY SUB-WATERSHEDS AT HIGH RISK OF SOIL EROSION, WHERE REFORESTATION AND EROSION CONTROL MEASURES WOULD ACHIEVE THE GREATEST DOWNSTREAM WATER QUALITY BENEFITS :

The total potential soil erosion of the entire basin was estimated at 53,154 (K tons/year). Vegetation cover retains 49,564 (K tons/year) of sediment while the remaining 3,418 (K tons/year) is exported to the Lukaya River. Soil erosion potential (USLE), sediment retention role and sediment export were estimated for each sub-watershed of the basin (**FIGURE 6**). The outputs show that: **a)** areas that currently export the highest amount of soil to the Lukaya River are degraded land and/or close to the river and **b)** vegetation cover is providing an important ecosystem service by reducing erosion potential. These findings helped identify priority areas for implementing erosion control measures (e.g. the Mafumba sub-watershed).

FIGURE 6. Relative soil erosion potential (left), amount of sediment retained (center) and amount of sediment exported to the river (right) by sub-watershed in the Lukaya River Basin

USLE
Ktons/year
- 0 - 483
- 483 - 1586
- 1586 - 4644

SEDIMENT RETENTION
Ktons/year
- 0 - 446
- 446 - 1542
- 1542 - 4499

SEDIMENT EXPORT
Ktons/year
- 0 - 25
- 25 - 78
- 78 - 176

OBSCOM 2015
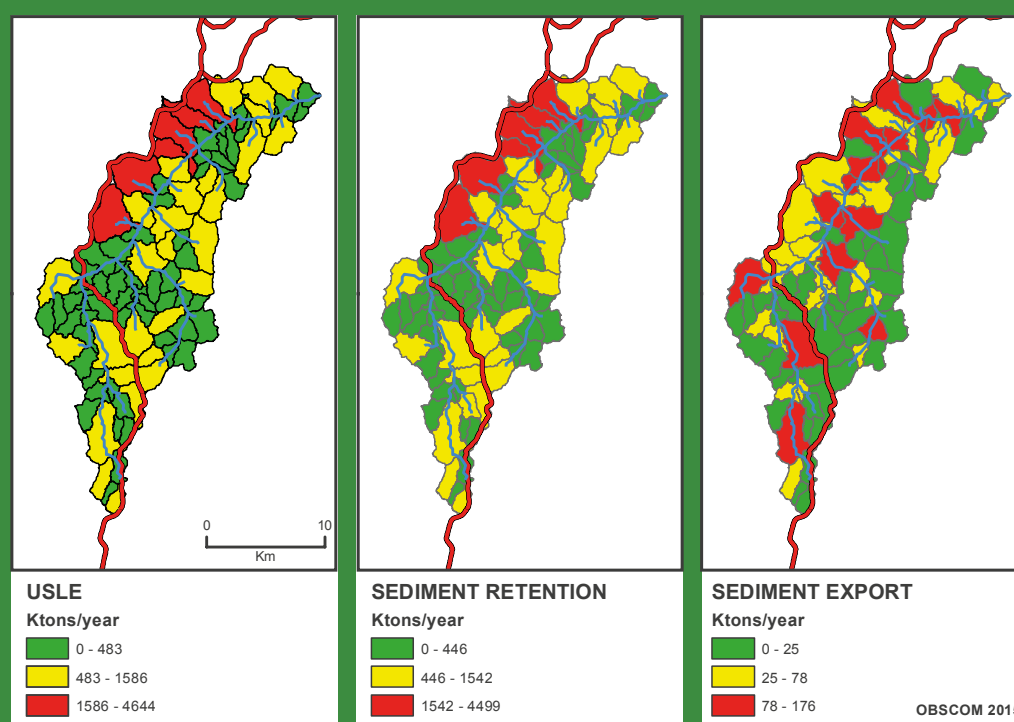
[10] *Key model inputs include elevation, land use and land cover (LULC), rainfall erosivity (i.e. duration and intensity of precipitation), and soil erodability (i.e. soil types), the stream network and sub-watersheds.*

OBJECTIVE 2:

EXAMINE THE IMPACT OF LAND USE CHANGE SCENARIOS ON SOIL EROSION AND SEDIMENTATION

The model was run under three land use change scenarios, focusing in and around Kasangulu town (17.57 km2), namely:

- **"CURRENT"** land use conditions;
- **"URBANIZATION"**, which assumes urban land as the predominant land use;
- **"REFORESTATION"**, which assumes restoration of forest cover as the predominant land use.

While they reflect observed trends of urbanization and the potential for reforestation, the scenarios were considered as simplified and extreme simulations to examine and visualize potential land-use changes in the future.

Model simulations revealed some of the environmental costs of unplanned urbanization (e.g. increased soil erosion and sedimentation), and the potential benefits of reforestation (e.g. reduced soil erosion and sedimentation) (**FIGURE 7**). In particular, expansion of the town of Kasangulu will increase potential soil erosion in the basin by 227 K tons/year (i.e. 0.43% increase), while an additional 203 K tons/year of sediment (i.e., 5.61% increase) will be exported to the river. In contrast, reforestation of the same area will reduce potential soil erosion by 1,400 K tons/year (i.e., 2.63% decrease), of which the quantity of sediment exported to the river will be reduced by 267 K tons/year (i.e. 7.88% decrease).

The findings were used to select the field intervention sites of the Eco-DRR project, in combination with field data collection, as well as community and Government consultations. For a full account of InVEST modelling on the Lukaya, a technical report is under preparation by UNEP.

FIGURE 7. A positive value means an increase in sedimentation per sub-watershed, while a negative value means a decrease in sedimentation.

b. URBANIZATION SCENARIO
Urban Land replaces Savanna and Bare Soil

c. REFORESTATION SCENARIO
Forest replaces Agriculture and Savanna

K tons/year

+ 50
+ 40
+ 30
+ 20
+ 10
0 - No change
- 10
- 20
- 30
- 40
- 50

0   2
Km

OBSCOM 2015
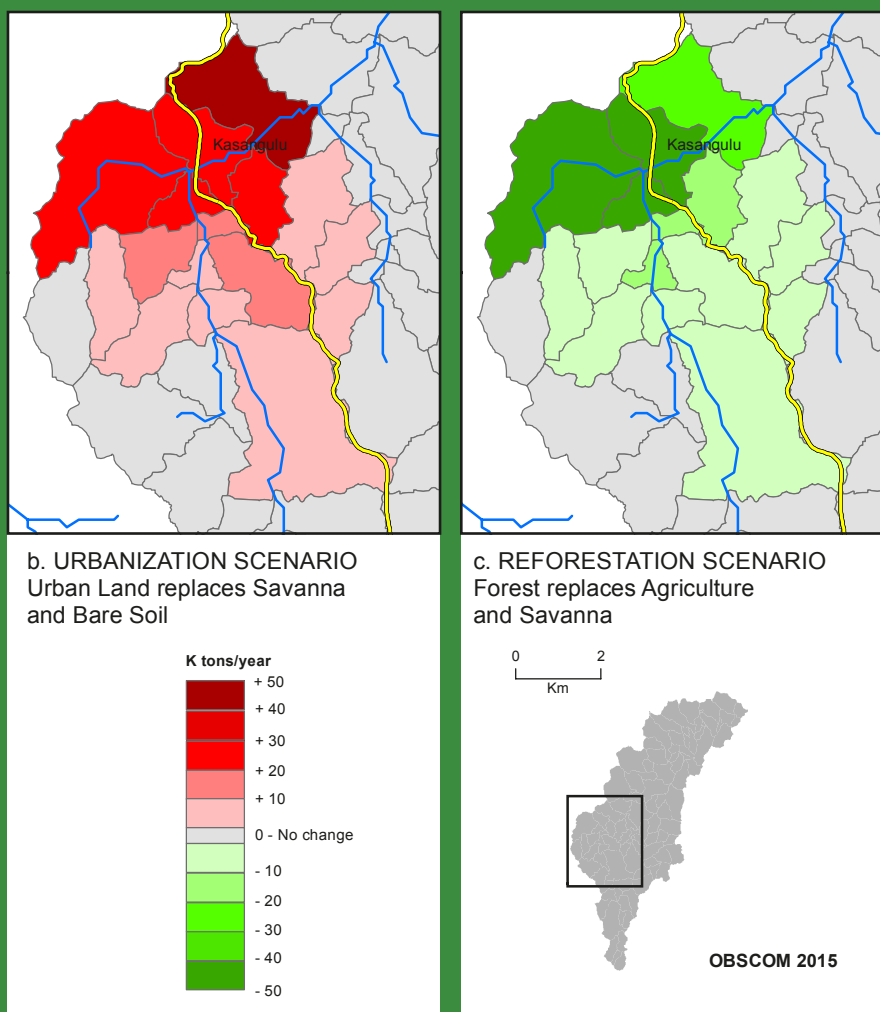
Hydro-meteorological monitoring and analysis

Hydrological and meteorological data are an indispensable knowledge base to estimate the current water availability in relation to water demand. Hydro-meteorological monitoring helps to assess the water balance in the basin and water resource dynamics in relation to climatic and human impacts (e.g. increased demand, pollution, land use changes), define objectives and plan for water resource allocation for various water usages (e.g. drinking water, dams, irrigated areas, etc.). Meteorological data are also important for flood risk monitoring and early warning.

Hydrological and meteorological data were generated to support the development of the IWRM Action Plan for the Lukaya watershed. Data was used to produce hydrological models to inform land-use planning and map exposed areas to flooding.

Hydro-meteorological measuring instruments were installed in a few locations in the basin (see **FIGURE 8**). Two flow gauges (limnigraphs and moulinet kits) were installed to measure the water level and the flow of the river in Kasangulu and Kimwenza, respectively. A mini-meteorological station (in Kimwenza) and two pluviographs (in Kasangulu and Mvululu) to monitor rainfall were also established.

For better use of information collected, the project established a hydro-climate advisory network between AUBR/L, REGIDESO, the Water Resources Directorate under the MECNDD, and the National Agency of Meteorology and Remote Sensing by Satellite (METTELSAT), to collaborate on data collection and provide early flood warning. METTELSAT is the national agency in charge of observation and monitoring of weather and climate information.

Through a Memorandum of Understanding with AUBR/L, METTELSAT is supporting AUBR/L to develop a harmonized database based on standards set by the World Meteorological Organization (WMO) and to prepare weather reports. The MoU will also pave the way for registering the monitoring stations in the Lukaya in METTELSAT's national directory. The Water Resources Directorate will help collect hydrological data using the limnigraphs, prepare monthly data analysis, initiate climate monitoring, as well as hydrological modelling in the watershed.

Given that the hydro-meteorological data collection requires daily monitoring and sustained measurements, the coordination body of AUBR/L located in the basin is in the best position to undertake this task and carry out regular visits to the stations. Data collected is stored and shared with the Water Resources Directorate and METTELSAT.

An early warning system for flood risk that is tailored for the Lukaya River basin could be developed, but long-term data monitoring is needed. In the future, the water treatment plant of the N'djili river (downstream) could also benefit from the monitored data and receive early warning of high water levels. So far, the instruments have allowed collection of data and analysis of precipitation and river flows, which facilitated the initial flood risk modelling of the Lukaya River basin (discussed further below).

Local hydrological experts from the Department of Soil Physics and Hydrology of the General Commission for Atomic Energy/Regional Centre for Nuclear Studies in Kinshasa (CGEA/CREN-K), a Government research center, were consulted from the start of the project and supported the installation of instruments and delivery of trainings to AUBR/L, Water Resources Directorate and METTELSAT on data collection and analysis. The establishment of hydro-meteorological monitoring systems and technical capacity building have enabled key players in the water sector, namely AUBR/L, Water Resources Directorate, METTELSAT and REGIDESO, to better understand and appreciate the value of hydrological monitoring that is needed to prepare for future floods.

Measuring river flow in Kimwenza

FIGURE 8. Example of a time series showing rainfall and the flow of the Lukaya River based on hydrometeorological measurements at Kimwenza
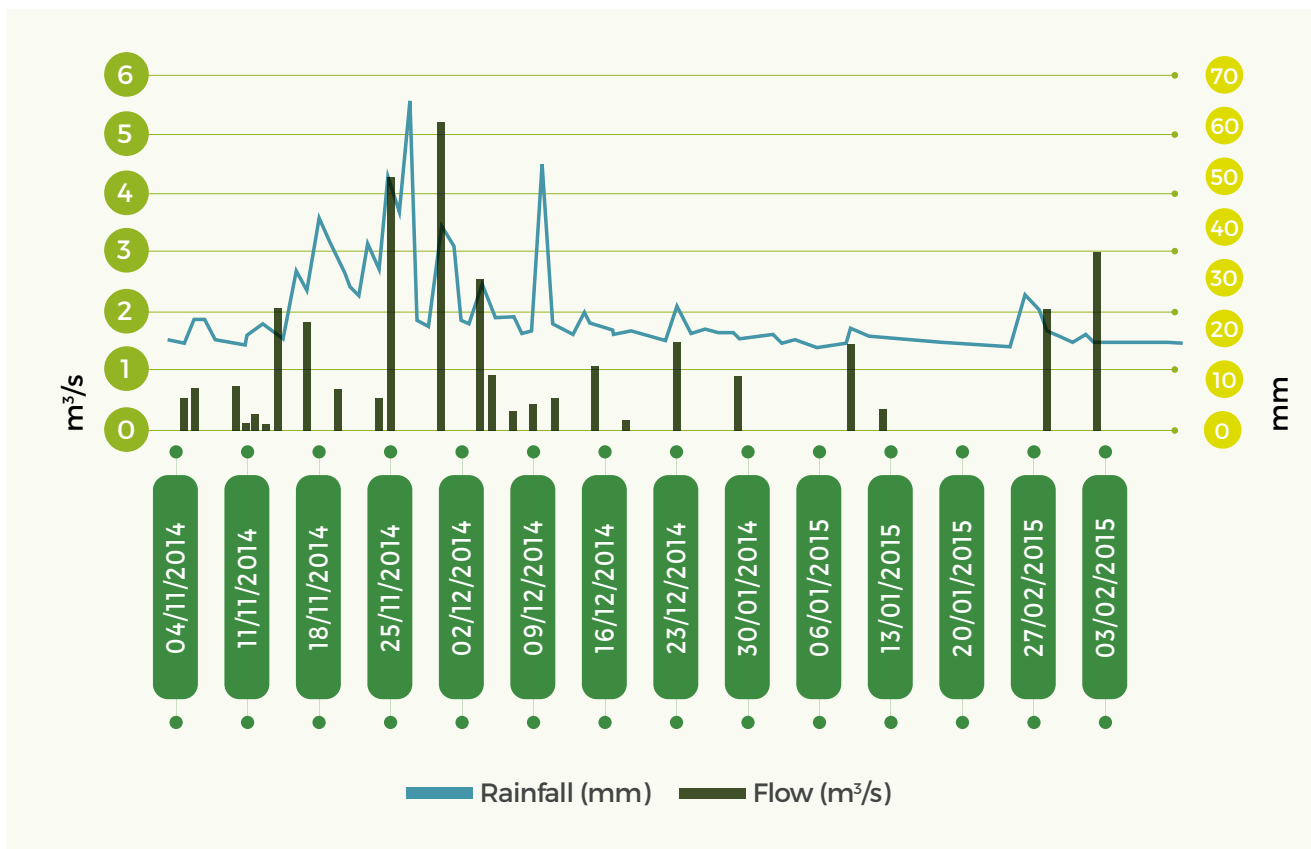
FIGURE 9. Initial floodplain map of the Lukaya River basin was developed based
on the Nile Basin Decision Support System (NBDSS) flood risk modelling

Legend

Stream_lukaya

10-year floodplain

50-year floodplain

100-year floodplain
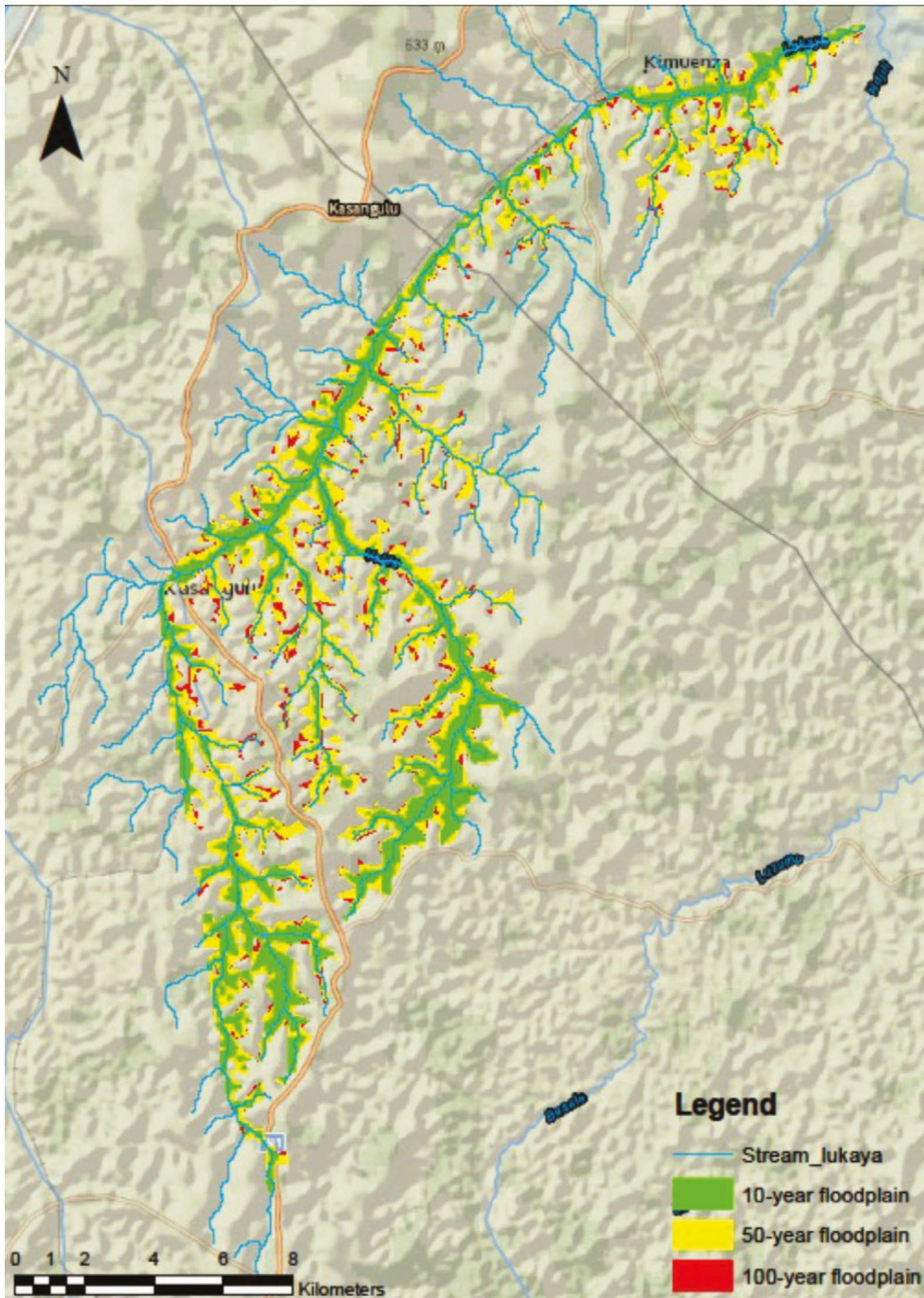
FLOOD RISK MODELLING AND MAPPING

As part of the local risk monitoring system established by the project, an initial flood risk map of the Lukaya River basin based on historical data was developed (**FIGURE 9**). Floodplains associated with 10-year, 50-year, and 100-year storm events in Lukaya were mapped using frequency analysis of daily rainfall depths of eight historical weather stations in the basin from the late 1950s to early 1980s.

Modelling of flood hazards and hydrology can shed light on the mechanism of floods and the extent of areas exposed to flood hazards in the basin, the result of which can be used to develop flood early warning systems and long-term flood risk management strategies. The flood map created complements the 3D participatory mapping carried out in the basin, and together they can be used in the future to inform land-use zoning and planning that takes into account flood risks and excessive sediment flux.

Surface run-offs resulting from precipitation events with specified re-occurrence intervals (also known as flood return periods) were calculated, which takes into account land use patterns, soil types, slopes and other characteristics of the watershed (**FIGURE 10**). Flood peak flows were estimated as the sum of base flow during the wet season and surface runoffs. River channel bathymetry (underwater depth) was reconstructed using the topographic map and two measured channel cross-sections. Potential water levels during floods were calculated in the Hydrologic Engineering Center's River Analysis System (HEC-RAS) model assuming steady state flow scenario. Water elevations were then inputted back to ArcGIS in order to map out the extent of floodplains.

FIGURE 10. Flood risk modelling procedure and input data.
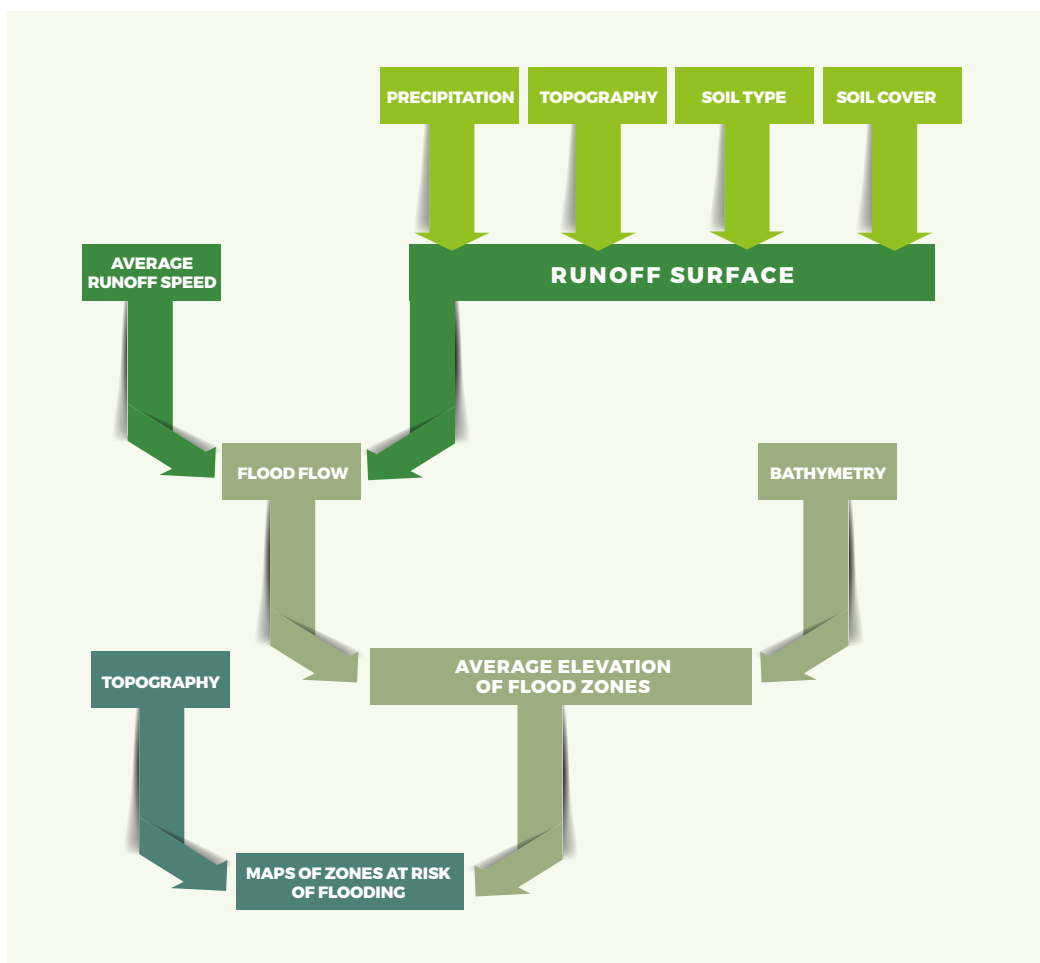
3.2. ECO-DRR FIELD INTERVENTIONS IN THE LUKAYA RIVER BASIN AND INITIAL RESULTS

The project implemented a number of ecosystem-based measures as pilot demonstrations of Eco-DRR within the IWRM approach. These field activities had several objectives. In the short-term, these activities aimed to restore vegetation cover in selected areas of the river basin in order to reduce soil erosion, river sedimentation and flood risk, while at the same time provide direct livelihood benefits to targeted households and stakeholders in the project. The project also aimed to establish locally managed systems and standard benefit sharing and work arrangement protocols, in order to sustain field interventions beyond the project's three-year lifespan.

It is important to highlight that the field demonstrations were undertaken at small scale, covering only a very limited geographic area within the basin. The intention was not to provide evidence of reducing the impacts of hazards (floods, storms, hurricanes), which would require field interventions at a much larger geographic scale and maintenance over a much longer time period that is beyond the scope and timeframe of this project. Rather, the project demonstrated how Eco-DRR measures could be implemented and reduce disaster risk in a river basin.

Field demonstration sites were located in two locations **1) UPSTREAM** and **2) DOWNSTREAM** (see **FIGURE 11** and **MAP 4** on page 50).

Nine nurseries (5 tree and 4 vetiver nurseries) were established in Ntampa, Kimwenza and Mafumba to supply trees and vetiver for the revegetation activities. Moreover, community members received training on innovative techniques of agroforestry, community tree nursery establishment and management, cultivation and plant reproduction, bioengineering using vetiver grass, as well as bush fire management and the marketing of products (discussed further in **SECTION 3.3**).

As discussed in **SECTION 3.1**, hydro-meteorological and river water quality monitoring instruments were installed in a number of locations across the watershed, which were undertaken in parallel with the other Eco-DRR field interventions.

UNEP partnered with the Centre for Integrated Development Support/Mbankana (CADIM), a national non-governmental organization (NGO) established in 1996 whose expertise is on sustainable farming systems. The Vetiver Network also partnered with UNEP to undertake bioengineering activities using vetiver for gully erosion control.

9

NURSERIES:

5 TREE AND **4** VETIVER NURSERIES WERE ESTABLISHED IN **NTAMPA, KIMWENZA** AND **MAFUMBA** TO SUPPLY TREES AND VETIVER FOR THE REVEGETATION ACTIVITIES

FIGURE 11. Field demonstration sites were located in two locations

FIELD SITE

1

UPSTREAM

- **Source of the river near the village of Ntampa** in Kongo Central Province - Activities in this area focused on revegetation through community agroforestry and reforestation to reduce soil erosion and sedimentation in the Lukaya River at the source;

- Activities focused on establishing hydro-meteorological and river flow monitoring instruments and an Eco-DRR/IWRM information center, where the 3D map is showcased.

2

DOWNSTREAM

- **Mafumba sub-watershed** near Kinshasa which is experiencing high risk of soil erosion and anarchic urbanization - Activities in Mafumba focused on piloting a soil erosion monitoring methodology and gully erosion control through bioengineering;

- **Kimwenza** - Vetiver grass and trees were used to control river bank erosion and establish a green buffer zone at the REGIDESO water treatment plant. The office of AUBR/L's downstream committee was also established in the compound of REGIDESO.

ECO-DRR FIELD INTERVENTIONS UNDERTAKEN

- Community agroforestry (15 ha) including beekeeping
- Reforestation (5 ha)
- Tree plantings around settlements (5,557 trees)
- Four community tree nurseries established (total capacity 42,000 seedlings)
- Soil erosion control with bamboo
- Rainfall (hydrometeorological) and river water level (flood) monitoring instruments installed at Kasangulu REGIDESO and the Catholic Mission in Mvululu
- Eco-DRR & IWRM information Kiosk with 3D maps installed at Kasangulu Territorial Administration Office
- 2 ha agroforestry replicated independently by private land owner in Mvululu

- Vetiver nurseries established (4 nurseries with a total of 32,000 vetiver plants)
- River bank stabilization with vetiver bioengineering techniques
- Green buffer zone around Kimwenza REGIDESO; 9 natural springs protected with moringa trees
- Reforestation on slopes (2 ha) and river banks with 3,000 acacia and 1,000 fruit trees
- Community tree nursery established (3,000 seedlings)
- Green walls established around houses with fruit trees to protect from flooding
- Soil erosion monitoring system with pins established
- Rainfall (hydrometeorological) and river flow (flood) monitoring instruments installed
- AUBR/L office established in Kimwenza REGIDESO compound
- Eco-DRR & IWRM information Kiosk with 3D maps installed at Lola ya Bonobo sanctuary
- 2 ha agroforestry replicated independently by private land owner in Mangala

MAP 4. Map of Eco-DRR field interventions in the Lukaya River basin

Mafumba sub-watershed

Vetiver nursery

Monitoring erosion

5 ha of acacia plantation

Kimwenza

REGIDESO Water Treatment Plant

Hydromet monitoring station at Kimwenza REGIDESO Limnigraph for river water level monitoring

2 ha of agroforestry replicated by private land owner at Mangala

Green buffer zone around Kimwenza Regideso with vetiver and moringa species. AUBR/L office established

Vetiver nursery

Limnigraph for river water level monitoring

Kasangulu

Information kiosks with 3D maps installed in Lola Ya Bonobo Sanctuary and Territorial Administration Office of Kasangulu.

Hydromet monitoring station at Kasangulu REGIDESO

Lukaya Watershed

Rainfall monitoring instrument at the Catholic mission of Mvululu
2 Ha of agroforestry replicated by private land owner

15 Ha of agroforestry with beekeeping
2 Ha of reforestation on the slopes
Fruit trees distributed to households
Bamboo planting to reduce erosion risk

Source of the Lukaya River

Ntampa

0   3.5   7
Km

GCS: WGS 84
Datum: WGS 84

Sources:
ESRI Basemap
World Street Map

The boundaries and names shown and the designations used on this map do not imply official endorsement by the United Nations. UNEP 2015.

UPSTREAM FIELD INTERVENTIONS: PROTECTING THE SOURCE OF THE LUKAYA RIVER

Through close collaboration with the AUBR/L and consultations with local community residents, agroforestry and reforestation activities were designed and implemented near the source of the Lukaya River in Ntampa (**MAP 5**).

MAP 5. Map of intervention sites in Ntampa
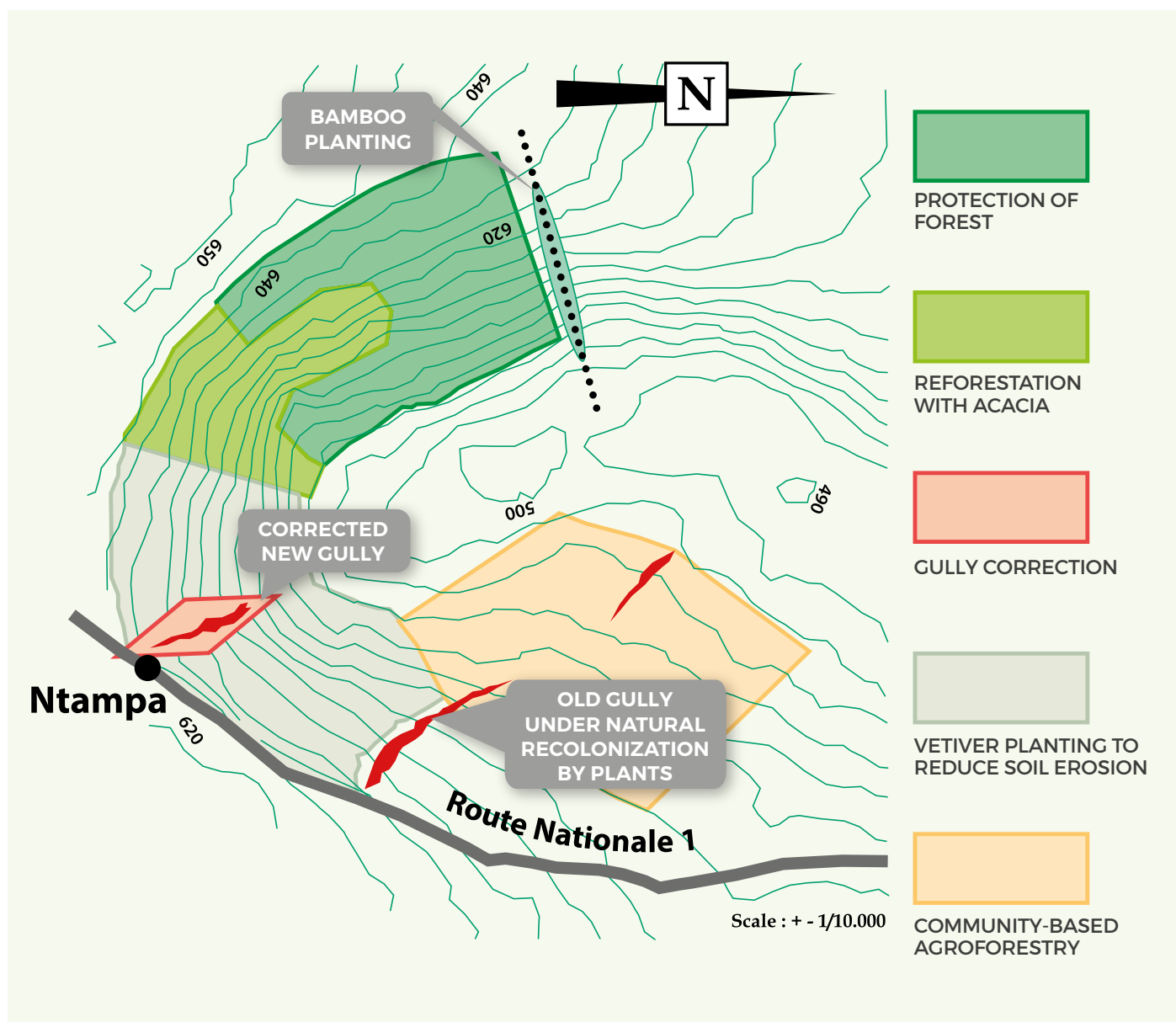
AGROFORESTRY

Agroforestry was established on 15 hectares (5 hectares established per year over 3 years) in Ntampa to provide additional livelihood support to 20 households. The households collectively cultivate the land and share the costs and benefits. It should be noted that 40% of farmers involved are women.

Before the project, the Ntampa community did not really practice agriculture and was mainly engaged in cultivating house gardens and charcoal production through slash and burn practices. Therefore, agroforestry represents an important livelihood innovation i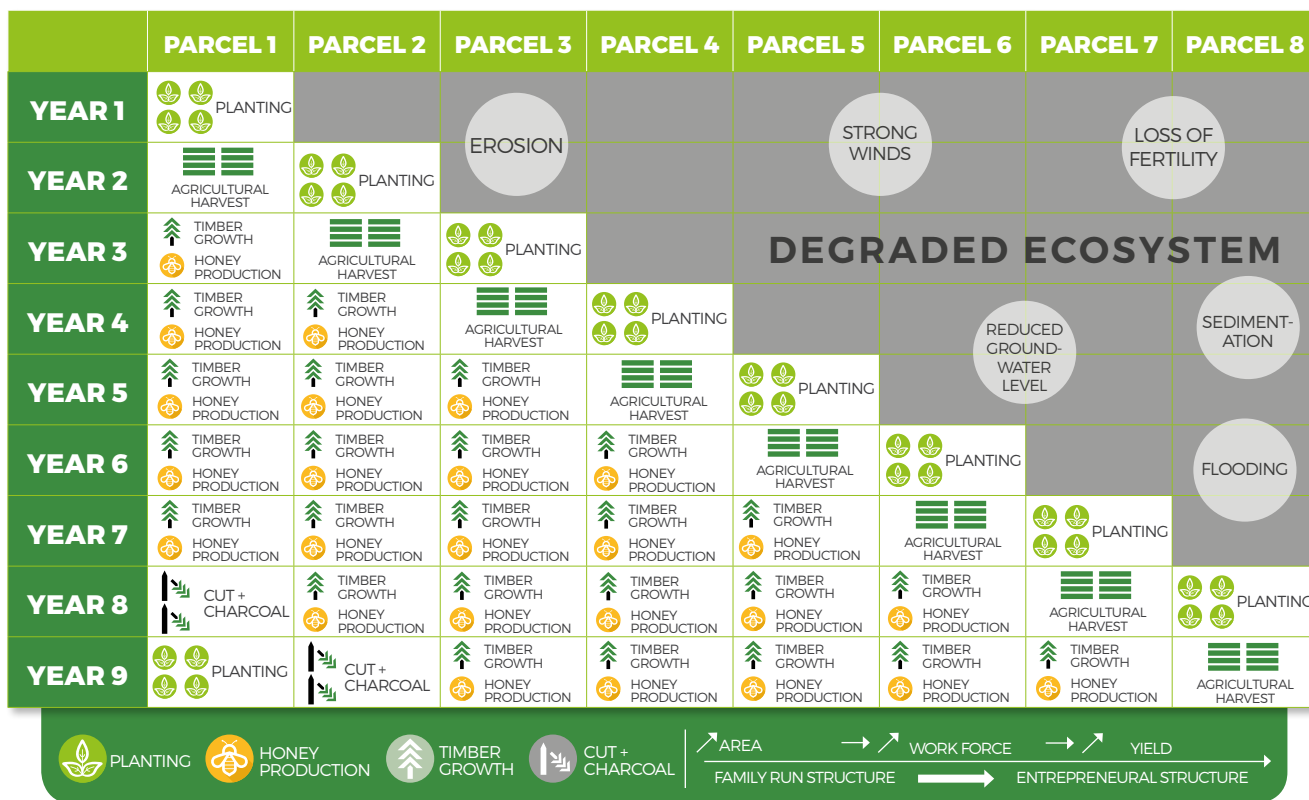n this area. Given the complexity of land tenure in the DRC, the project brokered an innovative benefit-sharing arrangement between the village chief, who manages available land in the village, the 20 households and AUBR/L. To protect cultivated agroforestry plots, community members agreed to prohibit grazing in the area.

The type of agroforestry introduced by the project is one of the few examples of a community-based agroforestry system in the DRC. It is based on an eight-year rotational cycle of crop production and forestry, which allows for the sustainable management of land and the reduction of soil erosion (**FIGURE 12**). One new parcel is equivalent to 5 ha and is established each year for eight successive years, after which the rotational cycle starts again on the same eight parcels. The same households manage all the parcels together; therefore, their income is expected to increase every year.

FIGURE 12. Management cycle of the agroforestry system. Each year one new parcel (of approximately 5 ha) is established.

	PARCEL 1	PARCEL 2	PARCEL 3	PARCEL 4	PARCEL 5	PARCEL 6	PARCEL 7	PARCEL 8
YEAR 1	PLANTING		EROSION		STRONG WINDS		LOSS OF FERTILITY	
YEAR 2	AGRICULTURAL HARVEST	PLANTING						
YEAR 3	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST	PLANTING		DEGRADED ECOSYSTEM			
YEAR 4	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST	PLANTING		REDUCED GROUND-WATER LEVEL		SEDIMENT-ATION
YEAR 5	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST	PLANTING			
YEAR 6	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST	PLANTING		FLOODING
YEAR 7	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST	PLANTING	
YEAR 8	CUT + CHARCOAL	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST	PLANTING
YEAR 9	PLANTING	CUT + CHARCOAL	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	TIMBER GROWTH / HONEY PRODUCTION	AGRICULTURAL HARVEST

Legend: PLANTING · HONEY PRODUCTION · TIMBER GROWTH · CUT + CHARCOAL

AREA → WORK FORCE → YIELD
FAMILY RUN STRUCTURE → ENTREPRENEURAL STRUCTURE

Gerkens M. adapted by C. Jacmain

Three types of plants are cultivated within a given parcel, namely acacia (Acacia auriculiformis), cassava and *niébé* (or cowpeas), which provide complementary benefits. *Niébé* is an azote-fixing leguminous plant which keeps the soil fertile for the cassava, a staple crop. Meanwhile, production of *niébé* and cassava, together with beekeeping, brings in revenue to farmers, which incentivizes farmers to keep the forest trees growing until they reach maturity (year 8). In the ninth year, mature acacia trees are cut on the first parcel, making room for agriculture and planting new acacia seedling. As such, forest cover is maintained, and farmers gain more income from selling charcoal made from mature trees.

This system also has nutritional benefits for households with low food security: cassava is an annual crop, while *niébé*, a short season crop, provides a good source of protein as well as revenue in-between cassava harvests. Species selection by CADIM, in consultation with local farmers, was based on a number of factors such as climatic conditions, resistance to disease, high yields and duration of growth. Cuttings of cassava, as seeds for initial establishment of the agroforestry systems, were acquired from the national agricultural research center in Mvuazi.


Planting at the agroforestry site in Ntampa

A Memorandum of Understanding (MoU) was established between the landowner (village chief), the 20 beneficiary households in Ntampa and the coordinating unit of AUBR/L, in order to ensure long-term results. Land was provided by the village chief and was selected based on soil profile and topography. AUBR/L's role is to sustain agroforestry activities and monitor the terms of the MoU agreement between the landowner and farmers. The MoU set an innovative arrangement, which distributes yields from agroforestry as follows: 50% for the producers (farmers), 25% for AUBR/L and 25% for the landowner (village chief in the case of Ntampa). AUBR/L puts aside seeds for planting in the next season, and uses its income from the rest of the harvest for covering planting and harvest costs, as well as internal expenses to provide technical support to farmers and monitoring the terms of the MoU.

THE SURVIVAL RATE OF AGROFORESTRY TREES PLANTED HAS BEEN

98%
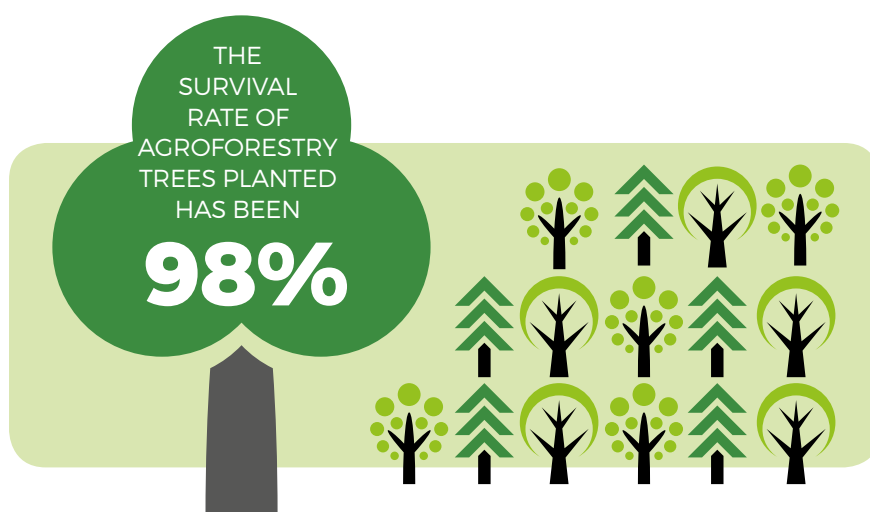
Agroforestry site during establishment (top), after one year (middle), and after three years (bottom)

COSTS

The most significant cost of agroforestry is investment in equipment (including beekeeping material) and setting up a land parcel. This amounts to 3,627.5 USD for the first hectare established but is reduced to 947 USD for every additional hectare, as some material are reusable. An additional 300 USD is incurred if land is prepared by tractor (price includes labor). In addition, the landowner bears the opportunity cost of land (this refers to the lost opportunity of earning income from renting or selling land for other purposes). The 25% share of income received is meant to cover this cost. It should be noted that land allocated for agroforestry in Ntampa was otherwise considered unsuitable for cultivation, which reduced this opportunity cost.

Finally, farming households bear the opportunity cost of labor (this refers to the lost opportunity of paid daily labor elsewhere) to work on agroforestry plots. In addition to four weeks of full-time labor to prepare a parcel of land (5 ha), the farmers work part-time during the rest of the year on charcoal production, maintenance (e.g. pruning), harvest and production of cassava chips.

BENEFITS

TABLE 2 shows the breakdown of revenue over time from each parcel (5 ha) of agroforestry. In the first year, revenue is already generated from charcoal production using the tree stumps that must be removed to cleared land (on average 3,000 USD from each parcel of 5 ha) and cultivation of *niébé* (on average 6,250 USD per parcel)[11]. This provides an incentive from the start to work in agroforestry. The following year, cassava is cultivated and harvested, bringing in additional revenue (on average 9,615 USD per parcel).[12] In the third year, beekeeping activities are initiated to further augment generated revenues and support pollination of crops. A minimum of 100 hives can be placed on each parcel, producing up to 1,000 litres of honey per year and bringing in 7,000 USD each year. In the eighth year, mature acacia trees are cut to make charcoal. Based on similar agroforestry schemes in DRC (e.g. Batéké plateau), around 1,750 bags of charcoal can be produced from each parcel, providing 35,000 USD in gross revenue. This system provides enough time for users to shift from slash and burn agriculture to more sustainable methods of farming. However, it is important to note that farmers must also be ready to work in a structured manner and take on the increasing workload.

TABLE 3 shows that agroforestry has a promising economic outlook if five new hectares are established per year and the cycle is fully implemented – i.e. 40 ha established over eight years. Up to 184,092 USD gross revenue could be accumulated over eight years. As explained above, all farmers collectively receive 50% of the revenue generated. Hence, revenue of farming households is increased by 394.36 USD per year (i.e. 3,155 USD accumulated over eight years). Given that agroforestry is a part-time job for most of the year, it can be a great incentive in DRC, where the average household income is 668.41 USD per year.

In addition to its economic gains, agroforestry increases forest cover (each year forest cover is maintained on seven out of eight parcels), reduces sedimentation and therefore mitigates flood risk. Re-greening the landscape also benefits biodiversity – as a first sign, rabbits have already returned to agroforestry sites. Additional longer-term benefits can be captured in monetary terms in future analyses, for instance in terms of reduced water treatment cost to REGIDESO, avoided flood damage and avoided soil loss. In addition, agroforestry not only benefits the households involved but also the larger community as it incentivizes village chiefs, who own community land titles, to keep the land, therefore reducing the risk of haphazard urbanization and land concessions.

SEED FUNDING

The Eco-DRR project provided seed funding for initial costs of establishing 5 ha per year for the first three years. AUBR/L is in discussion with The World Bank to receive additional support to continue agroforestry expansion on 5 ha per year over the next five years. However, if additional funds are not mobilized, the farmers will be able to establish 2 ha per year in the coming years using income already generated, therefore reaching a total of 25 ha by the end of eight years. In that case, gross accumulated revenue will be 139,845 USD over 8 years, and bringing in 384 USD additional revenue per year for each farming household.

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[11] *This is the present day value which takes into account the loss of money's value over time (7% discount rate).*

[12] *The time of harvest depends on the variety of cassava.*

TABLE 2. Revenue from 1 ha of agroforestry scheme in Ntampa. The revenue is shared among twenty households who collectively cultivate the land (50%), the land owner (25%), and AUBR/L (25%).

YEAR	
YEAR 1	3,000 USD from production of 100 bags of charcoal from stumps + 6,250 USD from harvest of 2,500 kg of *niébé*
YEAR 2	9,615 USD from 6,410 kg of cassava
YEAR 3-7	7,000 USD from 1,000 L of honey
YEAR 8	35,000 USD from 1,750 bags of charcoal produced from mature acacia trees

TABLE 3. Provisional economic outlook of a full cycle of agroforestry based on the scheme established in Ntampa. Each year a new parcel (5 ha) is established and cultivated collectively by the same 20 households that are involved in the agroforestry scheme.

		Parcel 1 (5 Ha)	Parcel 2 (5 Ha)	Parcel 3 (5 Ha)	Parcel 4 (5 Ha)	Parcel 5 (5 Ha)	Parcel 6 (5 Ha)	Parcel 7 (5 Ha)	Parcel 8 (5 Ha)	Gross Revenue	Present Value Gross Revenue (7% discount rate)	Present Value Revenue of Each Farming Household	Total area of agroforestry established (ha)
FIRST CYCLE	Year 1	9250	0	0	0	0	0	0	0	9250	$9,250	231	5
	Year 2	9615	9250	0	0	0	0	0	0	18865	$16,477	412	10
	Year 3	7000	9615	9250	0	0	0	0	0	25865	$21,114	528	15
	Year 4	7000	7000	9615	9250	0	0	0	0	32865	$25,073	627	20
	Year 5	7000	7000	7000	9615	9250	0	0	0	39865	$28,423	711	25
	Year 6	7000	7000	7000	7000	9615	9250	0	0	46865	$31,228	781	30
	Year 7	7000	7000	7000	7000	7000	9615	9250	0	53865	$33,544	839	35
	Year 8	35000	7000	7000	7000	7000	7000	9615	9250	88865	$51,720	1293	40
					Accumulated revenue after 8 years					**$316,305**	**$184,092**	**$3,155**	
SECOND CYCLE	Year 9	9250	35000	7000	7000	7000	7000	7000	9615	88865	$48,337	1208	40
	Year 10	9615	9250	35000	7000	7000	7000	7000	7000	88865	$45,174	1129	40
	Year 11	7000	9615	9250	35000	7000	7000	7000	7000	88865	$42,219	1055	40
	Year 12	7000	7000	9615	9250	35000	7000	7000	7000	88865	$39,457	986	40
	Year 13	7000	7000	7000	9615	9250	35000	7000	7000	88865	$36,876	922	40
	Year 14	7000	7000	7000	7000	9615	9250	35000	7000	88865	$34,463	862	40
	Year 15	7000	7000	7000	7000	7000	9615	9250	35000	88865	$32,209	805	40
	Year 16	35000	7000	7000	7000	7000	7000	9615	9250	88865	$30,102	753	40
	Etc	Etc	Etc	Etc	Etc	Etc	Etc	Etc	Etc	Etc	Etc	Etc	Etc

FIRST HARVEST OF *NIÉBÉ* (COWPEAS)

CASSAVA HARVEST FROM AGROFORESTRY SITE IN NTAMPA

COMMUNITY TREE NURSERIES

To provide trees for planting in the project, four community tree nurseries were established in the upper-watershed in the villages of Ntampa (with a capacity of about 35,000 seedlings of forest and fruit trees), Mvululu (2,500 seedlings of forest trees), Kingantoko (1,500 seedlings of forest trees), Mangala (3,000 seedlings of forest trees). In addition, a small nursery with a capacity of 3,000 seedlings was established in Kimwenza to provide acacia seedlings for the reforestation activities of the project. All of the nurseries except for the Ntampa nursery served primarily to encourage tree planting around housing settlements and for home gardens.

The Ntampa nursery was the largest in size, with a surface area of 400 m^2 and grew several varieties of fast-growing species to support agroforestry and reforestation activities (**TABLE 4**). The source of the Lukaya River served as an easy point for accessing water for the nursery. Preparation included delimiting the land, bagging seedlings, as well continuous weeding and thinning.

The 20 households who were involved in agroforestry were the same households who supported the Ntampa nursery. Each beneficiary household received 1,000 seedlings to plant in the nursery and contributed to the maintenance of the nursery. One selected community member was responsible for overseeing the management of the nursery.

The Ntampa nursery produced 17,653 seedlings in the first year (2014) with a survival rate of 95%. A low survival rate (approximately 20%) was observed for maesopsis sp., a non-native forest tree. The nursery is being used to experiment with crops and find the varieties that are most suitable to the climate of the Lukaya River basin. Therefore in 2015, leucaena (non-native shrub) and moringa (non-native tree) were selected instead as experimental species; to date, both species have shown a good survival rate.

TABLE 4. Varieties of plants and quantities sowed in the community tree nursery in Ntampa

N°		Variety	Number of sown bags in 2014	Number of sown bags in 2015
1	Native forest tree	ACACIA AURICULIFORMIS	10,980	17,200
2	Native forest tree	MILLETIA LAURENTII	4,340	8,645
3	Native forest tree	TERMINALIA SUPERBA	120	2,500
4	Cultivated forest tree	MAESOPSIS SP.	2,700	
5	Non-native shrub	LEUCAENA SP.		2,800
6	Non-native tree	MORINGA SP.		2,450
TOTAL			**17,653**	**34,595**

COMMUNITY TREE NURSERY IN NTAMPA

REFORESTATION

The seedlings of native trees produced in the nursery - such as limba (*Terminalia superba*) and wenge (*Milletia laurentii*) - were planted on 10 hectares of degraded slopes, with the main objective of restoring forest cover. However, half of this reforested area was later destroyed by fire, which prompted local trainings on bush fire management (discussed in **SECTION 3.3**).

Other degraded slopes were revegetated with bamboos to reduce runoff and erosion, improve groundwater recharge and protect gully heads that were threatening the national road, a school and other buildings, and increasing river sedimentation. Fruit trees were also planted around houses to provide additional household incomes, but also as a measure against violent winds, which were identified as a hazard by the community. In total, 5,557 trees (acacia, maesopsis, limba and milletia) were planted.

The choice of demonstration site was based on a number of factors, such as the location of fresh water springs threatened by erosion and degraded slopes. Members of the clan Nguanina Kongo and the surrounding area were the primary beneficiaries of interventions in Ntampa. An agreement was established between the beneficiaries and the AUBR/L to undertake monitoring activities and secure benefits to community members, such as access to land. Firebreaks were put in place to protect agroforestry fields and reforestation areas against uncontrolled bush fires.

DOWNSTREAM FIELD INTERVENTIONS: IN MAFUMBA AND KIMWENZA

Gullies are particularly visible in the lowlands, such as around the Mafumba River, located midstream in the basin. During the development of the IWRM Action Plan in Lukaya, the fight against gully erosion was prioritized to reduce their impacts, especially the siltation of springs and streams in low lying areas. In order to treat and arrest the formation of gullies, the project implemented a bioengineering technique using vetiver, a grass known for its deep roots that can effectively control soil erosion.

Given the shortage of vetiver grass in Lukaya, it was necessary to set up nurseries to supply vetiver for anti-erosion measures. Carried out by AUBR/L members with the support of local authorities and the local community, four vetiver nurseries were set up in two areas, near the REGIDESO water treatment plant and in Mafumba. In each of these locations, one nursery grew vetiver in bags, while the other grew vetiver in the field, providing a steady supply to AUBR/L for distributing vetiver grass. In total, 32,000 vetiver plants were grown (**TABLE 5**). Nurseries established in the field were purposefully located around the houses of the community, in order for households to reproduce vetiver for planting in the coming seasons and have a continuous source of the grass.

Due to its location in the periphery of Kinshasa, land tenure in Mafumba is a major issue, and only very limited land is available for implementing community activities. Fortunately, a local NGO - Oeuvre Chrétienne pour la Femme (OCF) - offered space for the vetiver nursery within its compound in Mafumba next to its school. OCF works closely with AUBR/L and is represented in the downstream river committee of AUBR/L. The vetiver nursery in OCF's compound has now been established as a permanent nursery, and is being used by the school for environmental awareness-raising. The project produced a comic book that explains, through engaging and simple illustrations, the use of vetiver for soil erosion control, which the school also uses for teaching purposes.

Vetiver nursery in Mafumba during (top) and after (bottom) establishment.

TABLE 5. Number of vetiver plants grown for erosion control

	MAFUMBA		KIMWENZA/RÉGIDESO		TOTAL
	In the field	In bags	In the field	In bags	
Number of nurseries	1	1	1	1	4
Number of plants	6000	10000	4000	12000	32000

Learning exchange: Visit of the AUBR/L members from Kasangulu to the nursery in Mafumba

Once nurseries were established, small-scale demonstrations of bioengineering techniques using vetiver were implemented together with community members (see **BOX 5** and **BOX 6** for the detailed methodology). The Mafumba sub-watershed was selected as one of the pilot sites because of the community's high level of concern about the extreme soil erosion and lack of means to control it. Moreover, the Mafumba River flows into Lukaya less than 1 km upstream of the REGIDESO water treatment plant, carrying high quantities of sediment. Prior to the project, the community was using ineffective (e.g. sand bags) or damaging (e.g. creating waterways on slopes for rainwater runoff) methods to fight erosion.

At the end of the rainy season in March 2015, a total of 8,000 vetiver plants were planted to stop the progression of gully erosion in the Mafumba sub-watershed. The Mafumba community showed great enthusiasm to experiment with new techniques, which have led to the stabilization of one gully that threatened the local school.

During project implementation, Mafumba experienced a number of flooding events, which resulted in severe erosion and losses of property. The project team therefore proposed to implement additional activities in affected areas, such as the establishment of "green" walls around houses using avocado and other trees. Despite heavy rains during the rainy season in November-December 2015, the gullies had not progressed, showing successful erosion control.

The two gullies in the Mafumba neighborhoods that were treated by AUBR/L members now serve to demonstrate the effectiveness of applying vetiver and bioengineering techniques for erosion control. A field visit was organized to bring residents from other parts of the basin (Kasangulu, Ntampa and N'djiliKilambu) to see the nursery in Mafumba and learn from the demonstration activities in this part of the watershed. The visitors took vetiver plants back to their communities and have expressed interest to set up vetiver nurseries in their respective sections of the basin. The AUBR/L is now well-capacitated in establishing vetiver nurseries and applying bioengineering techniques to support interested community members.

BOX 5. GULLY STABILIZATION TECHNIQUE USING VETIVER (*CHRYSOPOGON ZIZANIOIDES*) GRASS

STEP 1. PREPARATION OF SANDBAGS:

Used bags of rice, wheat flour, sugar etc. are filled with soil and placed successively in the gully heads, making sure they are compacted enough to maintain the cohesion of the soil particles in the bag. This helps to control the progression of active gully heads, which is a sensitive area, where significant runoff flows are concentrated and creates a strong erosive energy, due to the height of the drop and the turbulence generated by tearing of soil particles.

STEP 2. LAND DRAINAGE CHANNEL AND CREATION OF SAND AND SEDIMENT RETENTION THRESHOLDS:

The flow channel in the gully is a very fragile area, where the erosion process begins with slope scouring and then slippage. To avoid these situations, at every 10-15 m, sandbags (planted with vetiver; see next step) are placed in the gully channel, stacked to promote water flow without detaching soil particles (**FIGURE 13**). Sandbags capture sedimentation in the gully and the bottom of the gully gradually raises to the level of sandbags.

FIGURE 13. Diagram of gully control using piles of sandbags, which will then be planted with vetiver grass

GULLY HEAD STABILIZED WITH SANDBAGS

SEDIMENT-TRAPPING WEIRS EVERY 5-15M
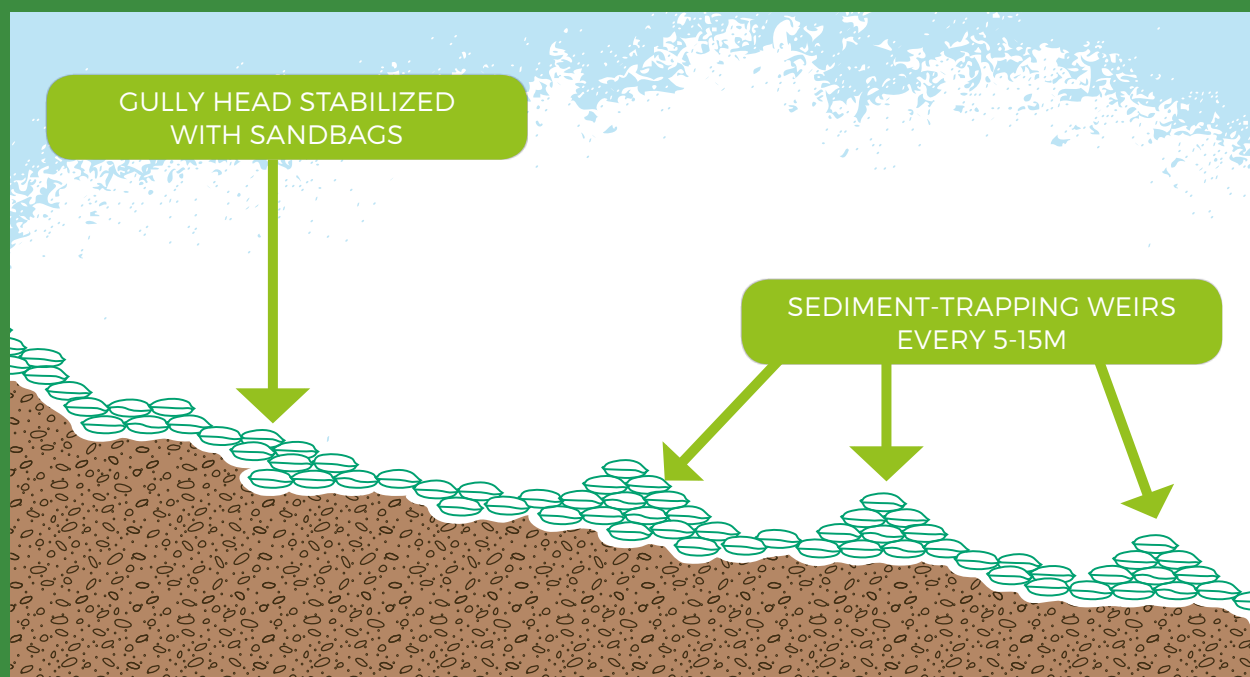
STEP 3. PLANTING VETIVER TO SECURE SANDBAGS AND RIVER BANKS:

Vetiver plants from community nurseries are transplanted on sandbags at 20 to 30 cm intervals. The top sandbags should be filled with fertile soil to allow the vetiver to flourish rapidly. As vetiver grasses grow, their long roots, which could reach 3 to 4 meters in the first year, anchor the sandbags inside the gully. The sandbags would normally deteriorate and breakdown under the sun, but the roots of vetiver keep the soil in place. It is necessary to monitor and replace plants that have not grown well after a month, to ensure proper stabilization of the soil.

**Gully stabilization in Mafumba using sandbags planted with vetiver grass:
before (TOP) and after (BOTTOM) intervention.**

REFORESTATION AND PROTECTING THE REGIDESO WATER TREATMENT PLANT IN KIMWENZA

A green buffer zone was established directly upstream of the intake point of the REGIDESO water treatment plant, which includes **1)** vetiver plantation on 1,200 linear meters of river bank to reduce river bank erosion (**BOX 6**), **2)** revegetation to protect the river bank and natural springs, which feed into the Lukaya River and **3)** a zone where horticulture is banned on public land to reduce water pollution from fertilizers.

Given the strong deforestation pressures in Kimwenza, 3,000 acacia seedlings, produced in the nursery site of Kimwenza, were planted. In addition, 1,000 seedlings of fruit trees were planted in plots to stabilize the banks of the Lukaya River. Fruit tree varieties (mango, avocado, mangosteen and safou trees) were selected based on the dietary preference of the communities. Moringa trees (Moringa oléifera) were also used to stabilize the river banks and various tributaries of the river in order to reduce river sedimentation. Nine natural springs across the Lukaya River basin were targeted for revegetation. These tributaries flow into the Lukaya just upstream of the intake point of the REGIDESO plant.

Staff from REGIDESO and members of the AUBR/L were trained in the appropriate application of the bioengineering methodology, monitoring and maintenance of the vetiver hedge, which requires replacing dead plants, weeding of unwanted grasses and fertilizer application during the dry season to improve growth.[13] The vetiver nursery established near the REGIDESO is expected to supply vetiver grass for the continuous replenishment of the buffer zone.

[13] NPK (nitrogen, phosphorus and potassium) fertilizer with urea was used during the dry season to minimize runoff.

BOX 6. RIVER BANK STABILIZATION USING VETIVER GRASS

STEP 1. RE-PROFILING THE RIVER BANK

The surface of the river bank must be modified with shovel and spade to remove uneven projections and create a gentle slope where vetiver grass can be transplanted easily (**FIGURE 14**). If the river bank is heavily eroded, gabions are also used in the re-profiling work.

FIGURE 14. Outline of riverbank re-modelling for moderately eroded slopes (cross section)
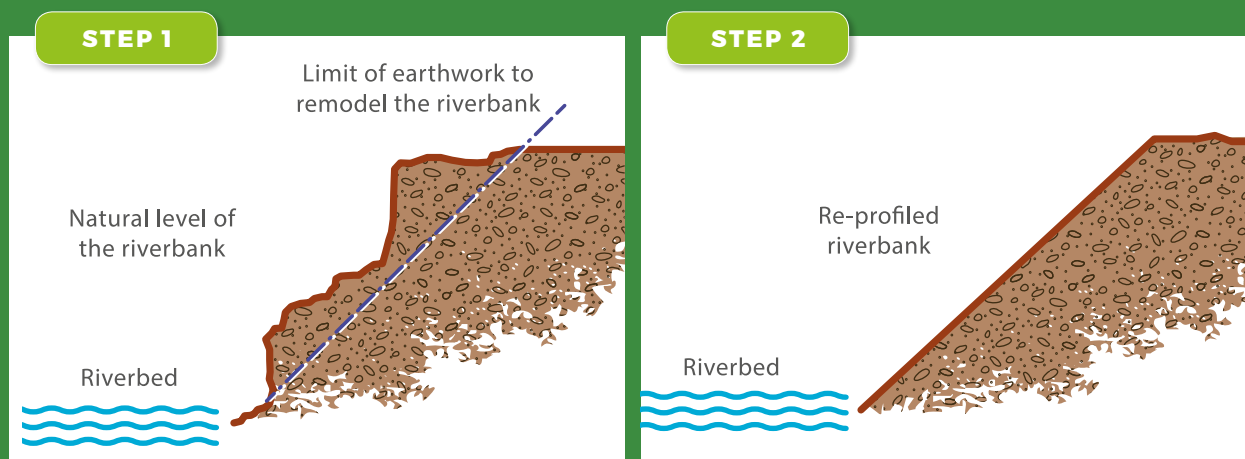
STEP 2. PREPARATION OF VETIVER SPLINTERS:

Vetiver thickets are divided into 2-3 splinters, with 5-10 cm long roots to ensure successful transplantation.

### STEP 3. PRE-PLANTATION OF VETIVER IN POLYETHYLENE BAGS FILLED WITH SOIL AND HUMUS.

Vetiver is left in pre-plantation phase for 45 days to grow new roots and leaves.

STEP 4. FINAL PLANTATION ON THE RIVER BANKS:

Vetiver grass are removed carefully from bags and planted on the remodeled slope. Small holes (1 m apart) are dug on the ground in the form of a mesh along the contour of the river bank, following the direction of

FIGURE 15. Diagram of vetiver hedge on river bank

Natural ground level

vetvier hedge in the form of a mesh

1m

1m

Section of the riverbank
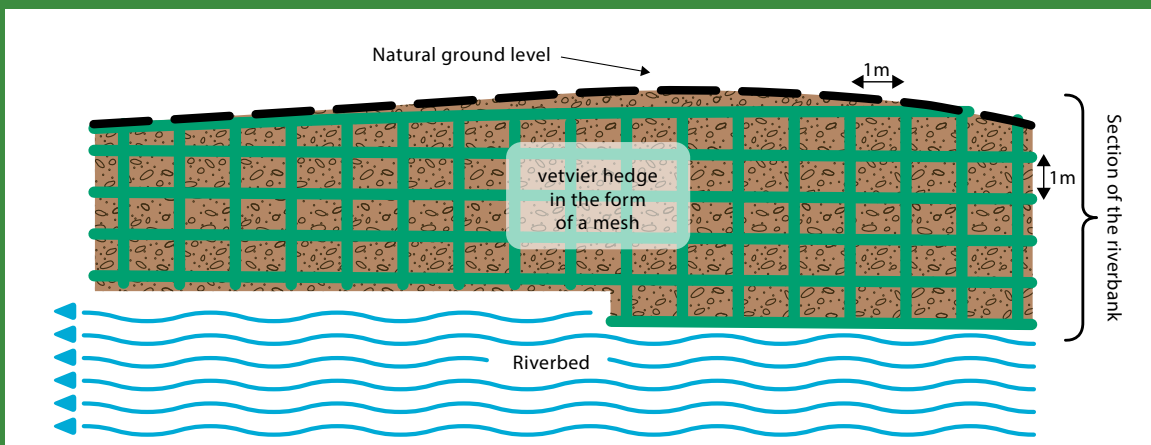
Riverbed

River bank stabilization using vetiver grass. Before (top) and after (bottom) intervention at intake point of the REGIDESO water treatment plant.

3.3. STRENGTHENING LOCAL AND NATIONAL CAPACITIES FOR MAINSTREAMING ECO-DRR IN IWRM

The Eco-DRR project also invested significantly in strengthening local and national capacities for mainstreaming Eco-DRR in IWRM implementation (**TABLE 6**). As this was DRC's first experience in applying both the Eco-DRR, as well as IWRM approach, it was critically important to progressively develop and strengthen capacities over time, which involved:

- **AWARENESS-RAISING;**
- **TRAININGS AND WORKSHOPS;**
- **HANDS-ON LEARNING ACTIVITIES IN THE FIELD DEMONSTRATION SITES;**
- **FIELD VISITS AND STUDY TOURS BOTH IN THE COUNTRY AND THE REGION.**

AWARENESS-RAISING

FIELD VISITS AND STUDY TOURS BOTH IN THE COUNTRY AND THE REGION

TRAININGS AND WORKSHOPS

HANDS-ON LEARNING ACTIVITIES IN THE FIELD DEMONSTRATION SITES

A TOTAL OF
71
TRAININGS AND WORKSHOPS

43 TARGETING LOCAL PARTNERS; **25** TARGETING BOTH NATIONAL AND LOCAL PARTNERS; **3** TARGETING REGIONAL CENTRAL AFRICAN COUNTRIES AND INTERNATIONAL ORGANIZATIONS GIVING STAKEHOLDERS

152 DAYS
OF FIRST-HAND EXPERIENCE WITH
ECO-DRR AND IWRM

Constructing the
3D map of the
Lukaya River Basin

Types of trainings or workshops delivered	Implementing partner/s	Target audience	Number of trainings/ workshops and duration	Number of participants
WORKSHOPS RELATED TO IWRM, ROLE OF ECO-DRR IN IWRM, ACTION PLANNING				
Basic knowledge on IWRM + Basic knowledge on Eco-DRR principles linked to IWRM	University of Liège & UNEP	AUBR/L members; MECNDD; Ministry of Agriculture, METTELSAT; University of Kinshasa	1 (5 days)	30
Restructuring of AUBR/L and establishing committees	AUBR/L & UNEP	AUBR/L members	5 (1 day each)	98
3D mapping of the Lukaya River basin	UNEP + Centre Technique de Coopération Agricole et Rural (CTA) + AUBR/L	AUBR/L, MECNDD	2 (16 days: 11 days for Kimwenza and 5 days for Kasangulu)	58
Methodology to develop the IWRM Action Plan, with Eco-DRR considerations	University of Liège & UNEP	AUBR/L members; MECNDD	1 (5 days)	40
Validation of the IWRM Action Plan	UNEP, AUBR/L, MECNDD	AUBR/L members	2 (1 day each)	32
Field visits to share the Lukaya watershed experience	Hosted by Congo Basin Network for Research and Capacity Development in Water Resources (CB-HYDRONET), and Capacity Building Network in IWRM (CAP NET). UNDP, UNEPCICOS, and GIZ delivered technical sessions	University of Zimbabwe, Ministry of Agriculture of Swaziland, ECCAS Gabon, University of South Africa, A representative of Global Water Partnership for Central Africa, COCOS Water Net of Zimbabwe, University of Namibia, District water office of Zambia and other countries	1 (1 day)	34
Exchange of findings and presentation by the students of ERAIFT to the AUBR/L on the results of their 3 weeks training about sustainable management of peri urban watershed into the Lukaya basin	ERAIFT; UNEP	AUBR/L	1 day	16 (AUBR/L) + 32 (students)
NATIONAL AWARENESS RAISING ON ECO-DRR AND IWRM				
National Training Workshop on Eco-DRR	UNEP, MECNDD, Ministry of Interior, Ministry of Social Affairs, Humanitarian Action and National Solidarity	National Government staff, including from the Bureau of Land Use Planning and the three organizing Ministries; CICOS; and civil society: CADIM, Centre d'Appui aux Actions Sociales de Développement/CASD), andUniversity of Kinshasa	1 (4 days)	35
National Working Group on Eco-DRR	UNEP, UNDP	MECNDD, Ministry of Interior, Ministry of Social Affairs, Humanitarian Action and National Solidarity	5 (1 day each)	4-5
Validation of the IWRM Action Plan	UNEP, AUBR/L, MECNDD	AUBR/L members	2 (1 day each)	32
SOIL LOSS MONITORING AND BIOENGINEERING TO REDUCE SOIL EROSION				
Basic knowledge on soil loss monitoring	UNEP	AUBR/L, Ministère des Affaires foncières + Local authorities	1 (2 days)	25
Basic knowledge on bioengineering and on technical use of vetiver to reduce erosion risks	UNEP	AUBR/L	6 (1 day each)	175

Types of trainings or workshops delivered	Implementing partner/s	Target audience	Number of trainings/ workshops and duration	Number of participants
AGROFORESTRY AND VALUE CHAIN PRODUCTION				
Agroforestry techniques	CADIM	AUBR/L	6 (1 day each)	240
Agroforestry nursery establishment and growing of fruit trees	CADIM	AUBR/L	5 (1 day each)	200
Value chain production (for 3 crops: cassava, niébé, acacia)to support farmers in selling their harvests and reduce losses	CADIM	AUBR/L	7 (1 day each)	280
Bush fire risk management	CADIM	AUBR/L	2 (1 day each)	80
Bee-keeping	CADIM	AUBR/L, local authorities, local police	5 (1 day each)	200
Capacity building on management and accounting basics	CADIM	AUBR/L	6 (1 day each)	240
Promoting agroforestry and sharing of experience in Ntampa	AUBRL & CADIM	Land owners across Lukaya River Basin	1 day	25
HYDRO-METEOROLOGICAL MONITORING, SOIL EROSION MONITORING AND FLOOD RISK MODELLING				
Basic knowledge of meteorology and data collection from the meteorological station of Kimwenza + maintenance of the instruments	METTELSAT	AUBR/L, Water Resources Directorate, REGIDESO staff, Waterways Agency (RVF), Ministry of Hydrological Resources and Energy	1 (3 days)	10
Basic knowledge on hydrology + data collection from the limnigraph installed along the Lukaya river + river flow measurement (field practice)	CRENK	AUBR/L, METTELSAT, Water Resources Directorate, REGIDESO staff, Waterways Agency (RVF), Ministry of Hydrological Resources and Energy	1 (4 days)	16
Hydrological modelling	UNEP, CRENK	AUBR/L, METTELSAT, Water Resources Directorate, REGIDESO staff, Waterways Agency (RVF), Ministry of Hydrological Resources and Energy	1 (4 days) + 1 day	10 16
Basic knowledge on GIS + field practice on how to use a GPS	UNEP, CRENK	AUBR/L	1 (3 days)	10
Basic knowledge on water quality + water quality monitoring (field practice using GPS)	UNEP, CRENK	AUBR/L	1 (3 days)	12
Regional Training of Trainers with a field visit to the Lukaya basin to gain field practice of using measurement instruments	CICOS, UNEP	Technicians of the national hydrological services of CICOS Member States	1 day	72
Basic training on flood risk modeling	UNEP, CICOS, MECNDD	AUBR/L, Water Resources Directorate, METTELSAT, CRENK	1 (3 days)	25
Soil erosion monitoring	UNEP	AUBR/L, Ministry of Land Affaires	1 (2 days)	25
GENERAL				
Inception meetings	UNEP	MECNDD, AUBR/L	2 (1 day each)	76
Presentation mid-point project results to the MECNDD, METTELSAT, REGIDESO and AUBR/L	UNEP	MECNDD, AUBR/L, REGIDESO, METTELSAT	1 day	26
Presentation of the IWRM plan and project results to national policymakers, donors and technical partners in DRC	UNEP, MECNDD, AUBRL	Donors and technical partners: EU, DFID, JICA, KOICA, KFW, Belgian cooperation, USAID, GIZ, FAO, UNDP, UNICEF	1 day	37

DEVELOPING LOCAL CAPACITIES FOR MAINSTREAMING ECO-DRR IN IWRM

It is important to note that a major portion of capacity building took place in the field, as part of "learning-by-doing" through implementation of the field interventions (discussed in **SECTION 3.2**). At the local level, the project mainly focused on re-enforcing the capacities of the AUBR/L to implement Eco-DRR concepts into IWRM practice. However, the project also involved other civil society actors (NGOs, academia), private businesses, and various ministries from the National Government in the field-level trainings and site visits.

While the AUBR/L was already in existence prior to the project, its functional capacities remained nascent and limited. Therefore, the project delivered a series of awareness-raising and specialized trainings on a range of topics related to IWRM and Eco-DRR. Addressing disaster risks within the Lukaya River basin was identified as a key priority and linked to the sustainable development priorities of the watershed.

These trainings were intended to support implementation of the field interventions (see **SECTION 3.2**), but they were also designed to establish locally-managed systems, which could sustain field activities long after the project's lifespan and, more importantly, inform future land-use planning and flood risk reduction strategies in the basin. For instance, once the agroforestry sites were established, it was clear that local capacity building was needed on selling agroforestry harvests: the first harvest produced large quantities of cassava, but farmers were not able to sell their produce in an efficient manner, resulting in production losses. Also, uncontrolled bushfires were identified as a threat to agroforestry and reforestation activities; at the same time, bush fires increase the potential of soil erosion. In response, the project delivered additional trainings tailored to community needs, for instance on value chain production and bush fire management. The capacity built within AUBR/L on soil erosion and flood monitoring will be instrumental for the continuous gathering of data, which should inform implementation of the IWRM Action Plan.

DEVELOPING NATIONAL CAPACITIES FOR IWRM AND ECO-DRR

At the national level, trainings and workshops engaged primarily with National Government actors in order to more effectively inform national policies and promote Eco-DRR within an IWRM framework (see **TABLE 6**). Although the project had a major focus on field level capacity building, a key priority was to also link community-level activities to national-level systems, institutions and processes. The field demonstrations and trainings served as a basis for strengthening National Government capacities in order to sustain future implementation and replication of Eco-DRR measures. In this regard, the project established strong collaborations between local river users and National Government actors.

The 3D map of the Lukaya River Basin was used in trainings and workshops as a tool to demonstrate the concepts of IWRM and Eco-DRR.

UNEP trained the River Users Association and National Government agencies in hydrological and meteorological data collection

3.4. SUPPORTING NATIONAL ADVOCACY ON ECO-DRR THROUGH IWRM IMPLEMENTATION

Through its field interventions and multiple local- and national-level trainings and workshops, the project sparked national dialogue on the effectiveness of IWRM as an overarching framework to promote sustainable and disaster-resilient development. This increased national awareness has in turn translated into active engagement of National Government to develop a National Water Policy and a National Platform for Disaster Risk Reduction and contribute towards the newly-adopted global framework for DRR, known as the Sendai Framework (2015-2030). Moreover, the experience of the IWRM in the Lukaya River Basin has also captured regional attention, encouraging learning exchanges and study tours between countries in the region.

SUPPORTING DEVELOPMENT OF THE NATIONAL WATER POLICY

To support the Government of DRC in its national transition towards IWRM (as described in **SECTION 2**), UNEP and DHI developed a Roadmap to guide the development of a National Water Policy. In addition to articulating a vision for water resources management, the National Water Policy is aimed at elaborating on key issues which have not been sufficiently addressed in the newly-enacted Water Law. These issues include the institutional mandates and roles for water resource governance.

The Roadmap outlines the principal orientation and necessary steps in the elaboration of the National Water Policy, the principal stakeholders involved, an initial work plan, and a fund mobilization strategy. DRR is also highlighted in the Roadmap as a priority theme along with capacity building and cross-sectoral coordination. The Government formally adopted the Roadmap in August 2014, and discussions are ongoing with the African Development Bank and other donors to support elaboration of the National Water Policy.

ENGAGING IN THE POST-2015 NATIONAL AND GLOBAL POLICY AGENDA ON DRR

At the start of project implementation, in an effort to raise national awareness of Eco-DRR, UNEP and the Government through MECNDD held the country's first National Workshop on Eco-DRR in October 2013. Organized in collaboration with the Ministry of Interior and Ministry of Social Affairs, Humanitarian Action and National Solidarity, the four-day training introduced Eco-DRR concepts within the IWRM framework. It promoted cross-sectoral integration and mainstreaming of Eco-DRR in IWRM and other national development planning processes.

Following the National Training on Eco-DRR, National Government ministries expressed strong interest to establish a National Platform on DRR, cognizant of the DRC's commitment to deliver on the Hyogo Framework for Action (2005-2015), which at that time was the global framework on DRR. A National Eco-DRR Working Group was convened by UNEP and UNDP, which comprised the MECNDD, the Ministry of Interior and the Ministry of Social Affairs, Humanitarian Action and National Solidarity. This Group met several times to discuss the next steps forward.

Since then, draft legislation to set up a National Platform on DRR has been prepared, and UNDP through a project launched in 2015 is supporting its establishment. In parallel, UNDP is working with the South Kivu Province to set up its first Provincial Platform for Disaster Risk Reduction, given the high-level support from the Governor.

> " We welcome UNEP's efforts, who has been working since 2013 with the Water Resources Directorate, to implement a demonstration project of innovative solutions and real impacts "
>
> **HIS EXCELLENCY BIENVENU LYOTA, MINISTER OF ENVIRONMENT, NATURE CONSERVATION AND SUSTAINABLE DEVELOPMENT**

The project's success in raising awareness on Eco-DRR in the country was evidenced when the Government of DRC took the initiative to promote ecosystem-based approaches during preparatory discussions on the post-2015 global framework on DRR, now the Sendai Framework for Disaster Risk Reduction (2015-2030). The Government of DRC has taken full ownership of promoting Eco-DRR approaches through IWRM. For example, at the Africa Regional Platform on DRR, which was held in Abuja, Nigeria, in May 2014, the national delegation from DRC represented by the Ministry of Social Affairs put forward **Proposal 22**:

> **22. Ecosystem based approaches and related efforts to reverse environment and land degradation should be reinforced as a means to manage disaster risks and deliver multiple socio-economic benefits. These call for long term approaches to sustain healthy ecosystems. River basin organizations should be recognized as playing a key role and efforts should be made to leverage existing AU mechanisms in this regard. Monitoring environmental compliance and the enforcement of multi-lateral environmental agreements in government plans supports these efforts**

DRC's proposal was endorsed by Member States at the Africa Regional Platform, which was reflected in the outcome document. Strong references to ecosystem-based approaches continued to be articulated by Member States from Africa, including the DRC delegation, during the inter-governmental meetings held on the post-2015 global DRR framework in Geneva in July and November 2014, respectively, in the run-up to the Third World Conference on Disaster Risk Reduction held in March 2015 in Sendai, Japan.

FACILITATING LEARNING EXCHANGES BETWEEN COUNTRIES IN THE REGION

The project also supported south-south learning exchanges. For example in February 2016, a Congolese delegation from the Water Resources Directorate of the MECNDD and one representative of the AUBR/L attended a study tour to learn about Burkina Faso's experience in watershed management, considered one of the most advanced in francophone Africa.

UNEP also collaborated with the Congo Basin Network for Research and Capacity Building in Water Resources (CB-Hydronet) on a number of capacity building events (see **TABLE 6** in Section 3.3). In December 2013, an information exchange workshop on research and capacity needs on water resources of the Congo Basin was held in Kinshasa. Subsequently, UNEP presented at a "Regional Training of Trainers in IWRM Approach to Climate Change Impacts and Adaptation Measures" in Kinshasa (May 2014), organized by CB-Hydronet and attended by 33 participants from 13 African countries. The pilot project in the Lukaya served as a model for IWRM/Eco-DRR in practice, with a field visit to demonstration sites organized.

> " Before, each ministry was working in silos. But thanks to the Eco-DRR project we now meet regularly with the Ministry of Interior, the Ministry of Health, the Ministry of Social and Humanitarian Affairs, as well as NGOs and the private sector. The collaboration that has been created between AUBR/L, the Ministry of Environment and other ministries allows us to work together closely to manage water resources in an integrated manner. "
>
> **MR. BIENVENU MULWA,**
> **MINISTRY OF ENVIRONMENT,**
> **WATER RESOURCES DIRECTORATE**

4

HOW DID THE PROJECT CONTRIBUTE TO DISASTER RISK REDUCTION?

Horticulture (garden farming)
along the Lukaya River

As discussed in **SECTION 1**, disaster risk is understood as a composite of three main elements that must be present: hazards, exposure (i.e. people or assets located in hazardous locations) and vulnerability (i.e. the range of factors – social, physical, economic, environmental, cultural, political/institutional, etc. – that shape how hazards affect or impact on people and communities) (see **BOX 1**). The Eco-DRR project aimed to influence at least two components of the disaster risk equation, namely mitigating hazards and reducing local vulnerabilities.

It is important to bear in mind that project field interventions were implemented at a very limited geographic area within the Lukaya River basin. The intention was not to provide evidence of reducing the impacts of hazards (floods, storms/hurricanes), which would require field interventions at a much larger geographic scale and maintenance over a much longer time period that is beyond the scope and timeframe of this project. The project, however, applied Eco-DRR measures through IWRM implementation, in order to demonstrate how such measures can influence hazard mitigation and vulnerability reduction and thus contribute to disaster risk reduction. Further details about project interventions and results are found in **SECTION 3**.

MITIGATING HAZARDS

In order to address ecosystem degradation as a driver of disaster risk in the Lukaya River basin, the project promoted ecosystem-based measures to mitigate natural hazards, namely soil erosion/gully erosion and floods.

Agroforestry, reforestation (including bamboo) and bioengineering through vetiver were implemented upstream (in Ntampa and Kasangulu) to specifically reduce soil erosion and stabilize slopes, which were contributing to high river sedimentation and flood risks. Selection of trees and plant species was based on local community preferences, as well as their suitability to the climate and soils found in the Lukaya basin.

Downstream (in Mafumba and Kimwenza), bioengineering techniques through vetiver were applied to treat and stop the progression of gullies near settlements and schools, and reduce river bank erosion especially around the REGIDESO water treatment plant. Tree planting was also undertaken to stabilize river banks and reduce river sedimentation that contribute to flood risks.

REDUCING LOCAL VULNERABILITIES TO DISASTERS AND CLIMATE CHANGE IMPACTS

The project also served to reduce local vulnerabilities by implementing measures that:

- **Diversified local livelihoods and augmented household incomes;**
- **Developed local and national capacities to undertake Eco-DRR through IWRM implementation, including establishing local risk monitoring systems;**
- **Informed development policies and planning processes at local and national levels;**
- **Strengthened partnerships and collaborative initiatives on Eco-DRR.**

By helping to diversify livelihood sources and increase household incomes, the project will enable local communities to better cope with and manage disaster and climate risks. For instance, the agroforestry system with its 8-year cultivation cycle was especially designed as a community-based approach, in order to provide maximum returns to local residents. Its community-based, 8-year cultivation cycle is a new innovation introduced by the project and is unique in the country. New harvests of cowpeas and cassava, as well as the sale of charcoal generated from cleared agroforestry fields have augmented incomes of the 20 participating households. Additional livelihood activities, such as bee-keeping and fruit tree cultivation, have also been introduced to augment household incomes.

Moreover, vetiver bioengineering and tree planting have been undertaken to protect the upstream source of the Lukaya River, its tributaries and natural springs, which provide drinking water to local residents and the city of Kinshasa. Protecting drinking water supplies will also help to reduce

vulnerability to future disaster events, particularly flooding and drought.

Given the absence of river basin authorities in the DRC, the project has also invested significantly in strengthening local and national capacities for undertaking Eco-DRR through IWRM implementation (see **SECTION 3.3**). This has enabled local and national stakeholders to focus more efforts on disaster prevention and to address the multiple drivers of ecosystem degradation in the Lukaya basin that contribute to disaster risk. For instance, the project has established locally-managed soil erosion, hydro-meteorological and flood risk monitoring systems, which provide an initial basis for developing early warning systems for floods. The river gauging stations established by the project are easily accessible and are reportedly the only functioning stations in the DRC.

Through these various capacity-building processes, there is much stronger collaboration between AUBR/L, National Government technical agencies including the MECNDD, as well as other national and regional experts (University of Kinshasa, CREN/K, CICOS). This helps ensure greater recognition of environment and disaster linkages in development planning, as well as facilitate access to technical support for implementing ecosystem-based measures for DRR.

Promoting Eco-DRR through IWRM implementation in Lukaya highlighted the importance of linking upstream and downstream communities in tackling disaster risks within a shared river basin. The project supported Lukaya River users to develop a unified vision of sustainable development in the basin that is risk-informed, thus achieving a historical milestone on integrated river basin management in the country. The IWRM Action Plan for the Lukaya River basin clearly promotes Eco-DRR measures as part of sustainable development. In addition, the project has resulted in greater national commitment to mainstream Eco-DRR into national development policies, including the development of the National Water Policy. Draft legislation is now being prepared, with support from UNDP, to establish a National Platform on Disaster Risk Reduction, which will further enable national actors to focus on disaster prevention and promote ecosystem-based measures for DRR.

THE PROJECT APPLIED

ECO-DRR THROUGH IWRM IMPLEMENTATION,

IN ORDER TO DEMONSTRATE HOW SUCH MEASURES CAN CONTRIBUTE TO HAZARD MITIGATION AND VULNERABILITY REDUCTION.
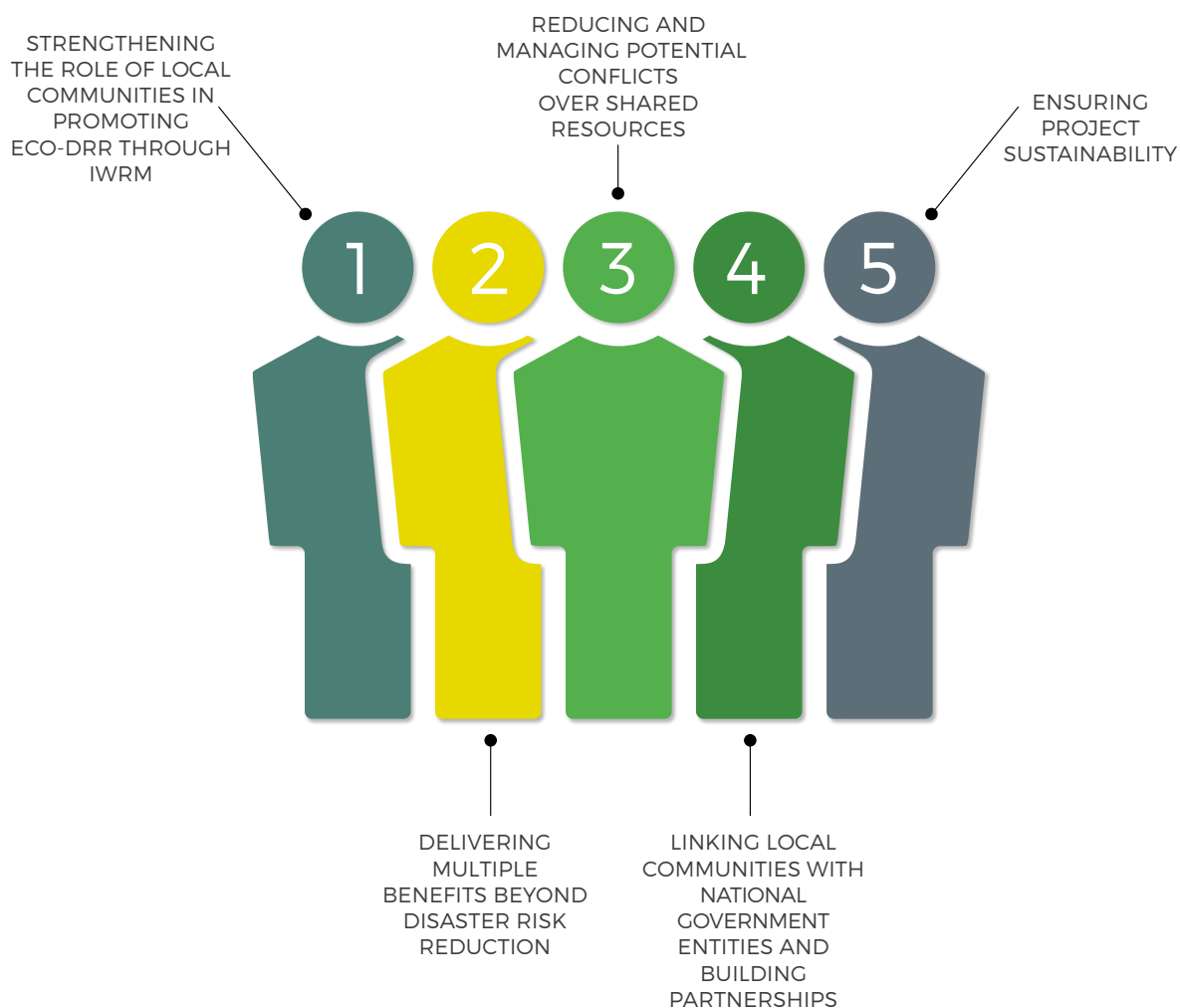
5 LESSONS LEARNED

Fisherman on the river

This final section reflects on the main lessons learned from our project, in order to inform design, implementation, replicability and sustainability of similar Eco-DRR approaches and initiatives in the DRC but also globally. The project clearly demonstrated that the Eco-DRR concept and approach can be applied through IWRM implementation. The results and experience gained through this first demonstration project in DRC can serve as a model for implementation of IWRM that supports sustainable ecosystem management and disaster risk reduction, in other basins of the country. Several factors, however, need to be considered to support project implementation, maximize results and outcomes and ensure sustainability.

LESSONS LEARNED

STRENGTHENING THE ROLE OF LOCAL COMMUNITIES IN PROMOTING ECO-DRR THROUGH IWRM

REDUCING AND MANAGING POTENTIAL CONFLICTS OVER SHARED RESOURCES

ENSURING PROJECT SUSTAINABILITY

DELIVERING MULTIPLE BENEFITS BEYOND DISASTER RISK REDUCTION

LINKING LOCAL COMMUNITIES WITH NATIONAL GOVERNMENT ENTITIES AND BUILDING PARTNERSHIPS

BOX 7. WOMEN AS ECO-DRR CHAMPIONS IN THE LUKAYA

Women, as community leaders, farmers and income earners, demonstrated high interest and showed strong engagement throughout the project. Several women in local leadership positions played a particularly influential role in Eco-DRR demonstration activities.

Madame Marie José MPELEKELA, the traditional chief of Kingantoko brought together the women of her clan and established an agroforestry site with support from the project. Her strong convening power and influential role in the community was not only key to the success of the agroforestry site, but also ensured engagement of her entire community in the meetings and decision-making processes of the river user's association. She is one of the two Vice-Presidents elected in the Upstream River Committee of the AUBR/L.
Image: Marie José MPELEKELA, village chief of Kingantoko.

Madame Marie Yobi , put all her energy to replicate the agroforestry plots developed in Ntampa on two hectares in Mvululu, her home village. With the support of the Catholic mission office in Mvululu, she successfully carried out agroforestry activities. She is also active in the Upstream River Committee.
Image: Madame Marie Yobi planting acacia in Mvululu.

Madame Kinja Beatrice, the secretary of the NGO Oeuvre Chrétienne pour la Femme (OCF), led the establishment and management of the vetiver nursery located in the school of the NGO Oeuvre Chrétienne pour la Femme (OCF). She was also an agroforestry champion and produced the best harvest of manioc and *niébé* in the agroforestry plots in Ntampa.
Image: Madame Kinja Beatrice proud of the vetiver nursery.

These influential women have been ambassadors of the Eco-DRR project in their communities, and their support will be key in sustaining and replicating Eco-DRR activities in Lukaya.

1 STRENGTHENING THE ROLE OF LOCAL COMMUNITIES IN PROMOTING ECO-DRR THROUGH IWRM

> " This project is our first experience of implementing IWRM in the country. The lessons learnt will help address the implementation of river basin organizations in a professional manner. "
>
> **MR. VINCENT KASULU,**
> **SECRETARY GENERAL OF MECNDD**

> " This experience should be replicated elsewhere because water resource management must be initiated from bottom up. "
>
> **MR. GEORGES GULEMVUGA,**
> **WATER RESOURCES DIRECTOR, MECNDD**

As discussed, the project clearly demonstrated that IWRM provides an effective framework for promoting Eco-DRR approaches. A key ingredient of successfully promoting Eco-DRR through IWRM in DRC was the sustained participation of local river users, through the AUBR/L.

The project was fortunate to have an existing local river basin management institution – the AUBR/L – already in place. At the time of project inception, the AUBR/L was still a very young, under-developed organization. Therefore, the project prioritized capacity development of the AUBR/L as the primary vehicle for engaging local communities in the Lukaya River basin. This strategy proved to be a critical success factor.

Working through the AUBR/L, the project was able to bring together key stakeholders from upstream and downstream communities in the basin. The AUBR/L convened traditional leaders and village chiefs, local residents and households, private entrepreneurs, NGOs and community-based organizations and REGIDESO (the public utility water provider). Organizing regular meetings between river users provided a space for continuous dialogue between upstream and downstream users.

Through AUBR/L's coordinating body, as well as the various upstream and downstream river user committees, sub-committees, clear roles and responsibilities could be established. Thus, the project could more easily deliver awareness-raising, capacity building and training, Eco-DRR field activities (agroforestry, reforestation, gully erosion control, etc.), monitoring and follow-up, through clearly designated AUBR/L entities.

However, it is important to underline that the relatively weak presence of central technical administration at the local level in post-conflict DRC favors a strong community-based approach in applying IWRM. The role of communities therefore needs to be adapted to the specific governance context of each situation. Moreover, in terms of scale-up and long-term sustainability, it is critical that such initiatives are progressively embedded in national institutions (discussed further below).

It is also worth highlighting that local communities within the Lukaya River basin are not homogenous. Different river users and stakeholders hold different roles and therefore exert varying influence and may have different interests and perspectives. Hence, identifying and working with local actors, who can play a convening role in the project is important. In this case, the village chief in Ntampa played a critical role by agreeing to designate land for participating households to implement agroforestry activities. The AUBR/L signed an MoU with the village chief to protect the agroforestry site over the long-term and to distribute the sharing of benefits among participating households.

Women as community leaders also played an influential role (see **BOX 7**). Their convening power and influence on other women nourished the project's community-based approach and drew in a more diverse group from the community in project activities and decision making. In turn, the project was able to better balance the interventions to meet the needs of both women and men, who sometimes had different perspectives based on their gendered roles and varied concerns.

2 DELIVERING MULTIPLE BENEFITS BEYOND DISASTER RISK REDUCTION

The overall success of the field demonstrations is evident by the strong community up-take of the interventions, guided by experienced local partners such as CADIM. From the outset, the project team emphasized the multiple benefits of Eco-DRR beyond disaster risk reduction. Ensuring that local communities obtain tangible benefits from Eco-DRR field activities was therefore key to obtaining and sustaining local buy-in.

For instance, agroforestry interventions demonstrated that local communities can benefit directly in terms of improved harvests and boost household incomes and food security. Prior to the project, local residents in the upper catchment practiced farming on a household scale and focused on charcoal production. They considered the land made available to the project as unsuitable for agriculture, and were not familiar with agroforestry techniques or their potential benefits. However, the agroforestry plots proved that farmed land could be made more productive and sustainable over the long term.

The use of vetiver for gully and soil erosion control was also very successful, because local residents immediately perceived the protection value provided by the vetiver, especially when sites are located near their homes, schools or public roads. Prior to the project, communities in the basin did not know about the effectiveness of vetiver grass as an erosion control measure. Now neighboring communities have shown great interest in replicating the bioengineering methodology.

In particular cases when tree plantings did not have a clear, demonstrated benefit to local communities, the project suffered setbacks. For instance, during local consultations, community members expressed concern about strong winds as an important hazard. Therefore, a number of acacia trees were also planted around residential areas as a natural barrier against strong winds, however without defining who would look after the trees and who would benefit. Hence, this activity had a low success rate, and the acacia trees planted in the village were removed or eaten by goats. This raised

an important lesson of defining community roles and responsibilities to secure project interventions, particularly in public areas.

3 REDUCING AND MANAGING POTENTIAL CONFLICTS OVER SHARED RESOURCES

By bringing different stakeholders together, the IWRM planning process openly recognized the multiple and conflicting priorities for water and land use, and supported different river users to work towards a shared development vision for the Lukaya River basin. As a result, the project strengthened the collaborative relationships between upstream and downstream river users, and contributed to reducing potential local conflicts over shared water resources. This does not mean that local conflicts over natural resources will not emerge within the basin. However, with a much stronger AUBR/L now in place to facilitate dialogue between river users, there is greater capacity locally to manage and work through potential conflicts.

For instance, establishment of the hydro-meteorological monitoring systems and the installation of limnigraphs initially met with some resistance from local enterprises operating at a nearby quarry. In this particular case, the AUBR/L together with the MECNDD discussed with company management to raise awareness and reach consensus, referencing the Water Law, which clearly states that river banks belong to the State. Thus, obtaining local buy-in was critical for allowing monitoring systems to take place without interruptions.

In another example, field activities supported by the project, such as agroforestry and reforestation, were primarily demonstration sites, which meant that only a handful of households could be involved and thus directly benefit from the field interventions. In one case, a reforestation site was deliberately set on fire by neighboring villagers, who were not involved in the agroforestry activities but wanted access to project benefits. In response, the project invited several neighboring villagers to participate in the agroforestry trainings.

In implementing field activities, it is important to be mindful of local sensitivities and ensuring that project benefits are shared as broadly as possible, in order to minimize conflict between resource users. Thus, selection of project beneficiaries must

be handled carefully and transparently, through support of well-established and respected local partners, such as AUBR/L and CADIM. It also highlights the limitations of pilot projects and the need to ensure the scale-up of such interventions so more people are able to benefit. In this regard, given the limited funding and scope of the Eco-DRR project, UNEP leveraged additional resources by aligning the Eco-DRR project with another project funded by the UN Development Account, which allowed agroforestry and reforestation activities to be replicated in other areas of the basin.

4 LINKING LOCAL COMMUNITIES WITH NATIONAL GOVERNMENT ENTITIES AND BUILDING PARTNERSHIPS

From the outset, the project team was mindful that the AUBR/L on its own, while now well-capacitated, would face enormous challenges in implementing and sustaining the IWRM process in the basin. Therefore, the project emphasized the importance of linking AUBR/L with the relevant National Government ministries and other partners.

The project ensured that National Government capacities to promote Eco-DRR through IWRM were also strengthened, alongside AUBR/L's, and that the institutional mandates and functions of Government were supported and not replaced by parallel structures or processes. For instance, hydro-meteorological and soil erosion monitoring and flood risk modelling were undertaken in close partnership between AUBR/L, REGIDESO and METTELSAT, personnel from the Ministry of Land, and the CGEA/CREN-K, respectively. AURBR/L's primary responsibility was to monitor field instruments and gather data, while data analysis and modelling work continued to be led by METTELSAT, the respective National Government entity, which has the institutional mandate to oversee this work.

The project also invested in building new partnerships in order to provide AUBR/L and National Government partners with greater exposure to IWRM and Eco-DRR best practices, and further enhance their capacities. For instance, the project facilitated a number of study tours within the Lukaya River basin, hosting other communities in DRC, as well as other countries in the region, including the Republic of Congo, Gabon, Central African Republic, Zimbabwe, Tanzania and Cameroon, among others, to visit the demonstration sites. In another instance, the project brought members from the AUBR/L and the Water Resources Directorate on a study tour to Burkina Faso to learn about their experiences.

The project also supported collaboration with CICOS, with the Lukaya basin serving as a training site for hydrological monitoring and flood risk modelling for water experts from the DRC and other countries in the region. In addition, collaboration

with DHI facilitated advisory support to the National Government for development of a Roadmap to formulate a National Water Policy. This Roadmap is influenced by the IWRM experience in Lukaya and makes specific reference to DRR and the role of local communities in IWRM.

5 ENSURING PROJECT SUSTAINABILITY

A major concern for any project, including the Eco-DRR project in DRC, is the project's sustainability beyond its limited lifespan. In this case, the Eco-DRR project was a 3-year intervention, which has yielded a number of successful results. Certainly, a number of challenges will constrain further up-take, replication and scaling-up of the approach in the country. These include, for instance gaining access to land for undertaking future reforestation or agroforestry activities, and the need to anchor income-generating activities to support the financial autonomy of community-based organizations including the AUBR/L. While there is no way to guarantee that the project activities and results will be sustained, we can reflect on a number of factors that support long-term outcomes:

FIRST:

The project has developed sufficient local capacities through the AUBR/L to undertake and manage agroforestry, reforestation, vetiver bioengineering systems, so they can continue to deliver long-term benefits to households. AUBR/L is now able to provide trainings independently and offer technical support to local residents. For instance, other community residents, including village chiefs, who have visited the agroforestry sites have expressed interest to replicate them in other areas of the basin. As a result, four additional hectares of agroforestry were covered through voluntary actions of other communities. In addition, AUBR/L has now a well-defined business model for maintaining agroforestry activities, based on an eight-year forest fallow cycle of trees for charcoal production and agroforestry, wherein benefits are shared between AUBR/L, the land owner and participating farming households.

SECOND:

The IWRM Action Plan provides a clear roadmap for AUBR/L to initiate new partnerships and mobilize additional resources. The Action Plan will be presented to donors in June 2016, and discussions with several donors are underway for future collaboration to undertake agroforestry activities in the upstream section of the watershed.

THIRD:

AUBR/L has now built strong ties with National Government institutions and universities, which help ensure that Eco-DRR through the IWRM approach will continue to receive support from multiple partners. For example, CICOS, CADIM, the Water Resources Directorate under the MECNDD, METTELSAT, the University of Kinshasa and ERAIFT have committed to maintain contact with AUBR/L and support them in implementing the IWRM Action Plan for the Lukaya River basin. In addition, the Upstream River Committee developed a reforestation and agroforestry project, which subsequently received funding from the Global Environment Facility (GEF) and will start in 2016.

FINALLY:

There is now greater national awareness and commitment from the National Government to promote Eco-DRR through IWRM, based on national and regional exchanges and official statements delivered in various global policy fora, particularly in the run-up to the Third World Conference on Disaster Risk Reduction in March 2015, in Sendai, Japan. Strong national sentiment has been expressed to develop the National Water Policy to support implementation of the new Water Law and to implement the Sendai Framework for Disaster Risk Reduction.

6 ACRONYMS, ABBREVIATIONS & REFERENCES

Forest near
the Lukaya River

ANNEX 1. ACRONYMS AND ABBREVIATIONS

ADIR	Association pour le Développement Intégral en Milieu Rural
AFOD	Association of Working Women for Development
AU	The African Union
AUBR/L	Association of the Users of the Lukaya River Basin
CADIM	Centre for Integrated Development Support/Mbankana
CAP NET	Capacity Building Network in IWRM
CASD	Centre d'Appui aux Actions Sociales de Développement
CB-HYDRONET	Congo Basin Network for Research and Capacity Development in Water Resources
CGEA/CREN-K	General Commission for Atomic Energy/ Regional Centre for Nuclear Studies in Kinshasa
CICOS	Commission Internationale du Bassin Congo-Oubangui-Sangha
CNAEA	National Action Committee for Water and Sanitation
CRENK	Centre Régional d'Etudes Nucléaires de Kinshasa
CTA	Centre Technique de Coopération Agricole et Rurale
DEM	Digital Elevation Model
DFID	Department for International Development of the United Kingdom
DRC	Democratic Republic of the Congo
DRE	Technical Directorate of Water Resources
DRR	Disaster Risk Reduction
EC	The European Commission
ECCAS	Economic Community of Central African States
Eco-DRR	Ecosystem-based disaster risk reduction
ERAIFT	The Regional School for Integrated Forest and Land Management
EU	The European Union
FAO	Food and Agriculture Organisation of the United Nations
GEF	Global Environment Facility
GIS	Geographic Information System
GIZ	The German Federal Enterprise for International Cooperation
GPS	Global Positioning System
ha	Hectares

HEC-RAS	Hydrologic Engineering Center's River Analysis System
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
KOICA	Korea International Cooperation Agency
LANDSAT	Land Remote Sensing Satellite Program
LULC	Land use and land cover
MECNDD	Ministry of Environment, Nature Conservation and Sustainable Development
METTELSAT	Meteorological and Satellite Remote Sensing Agency
MoU	Memorandum of Understanding
NBDSS	Nile Basin Decision Support System
NGO	Non-Governmental Organisation
NTU	Nephelometric Turbidity Unit
OCF	Oeuvre Chrétienne pour la Femme
P3DM	Participatory 3-dimensional mapping
PARGIRE	Regional Action Plan on IWRM
PRSP	The Poverty Reduction Strategy Paper
REGIDESO	Public water distribution agency of DRC
RRN	Network for Natural Resources
RVF	Waterways Agency
t	Tonnes
UGMK	Union of Horticulturalists Groups in Kimwenza
UN	United Nations
UNDA	United Nations Development Account
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD	United States Dollar
USLE	Universal soil loss equation
WMO	World Meteorological Organisation

ANNEX 2. REFERENCES

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