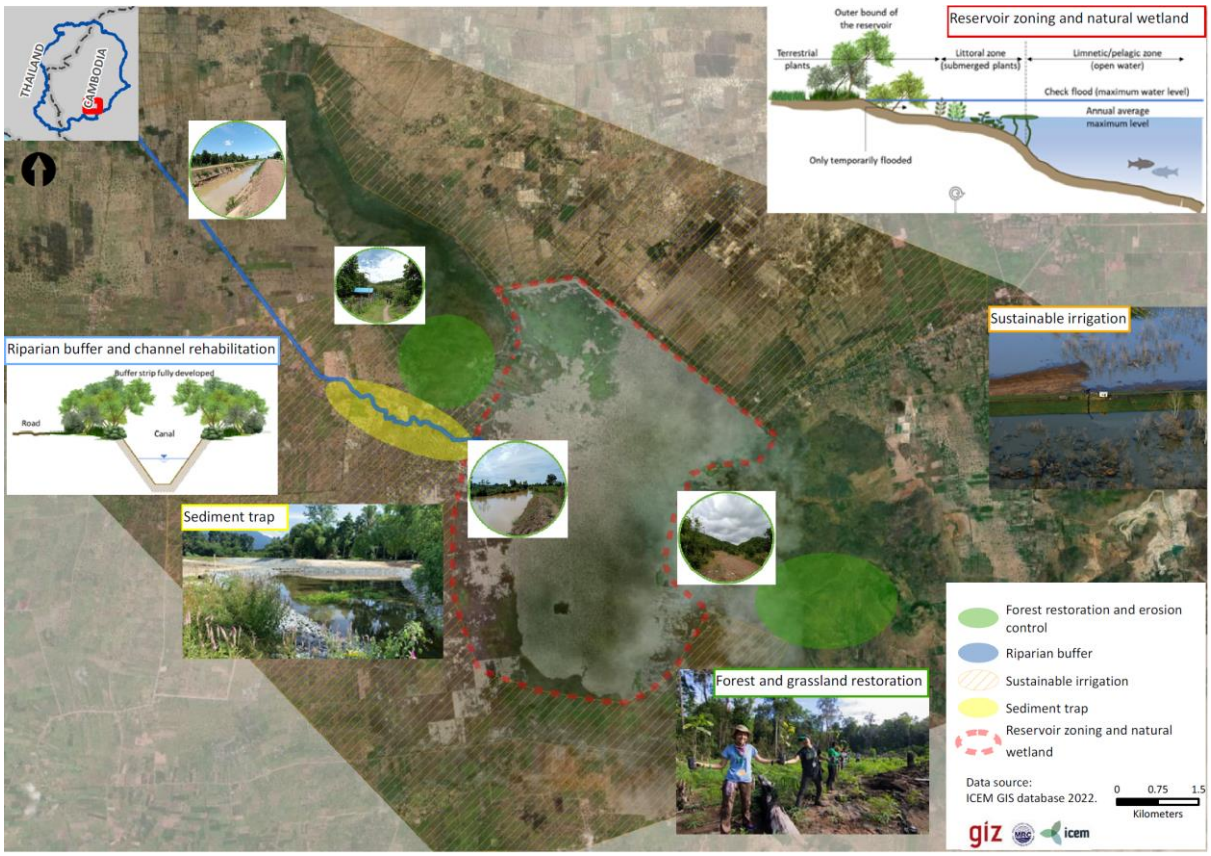
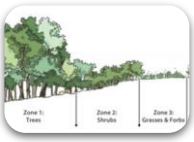
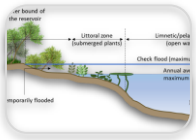
PROJECT 5: RESERVOIR – KAMPING PUOY RESERVOIR AND CATCHMENT, CAMBODIA

1. Project Overview





1. Riparian buffer



2. Reservoir zoning

3. Catchment water management

5. Sediment trap

6. Forest restoration and rehabilitation

13. Sustainable irrigation measures

Project 5 is a landscape which has a major reservoir, canals and irrigation system as its focus. The project seeks to restore the landscape to protect and prolong the life of those infrastructure assets through a network of NbS and hybrid measures. Problems to be addressed include wetland encroachment, flooding and erosion/sedimentation control. The project objectives for this landscape are:

- Define measures for reservoir, wetland and watershed rehabilitation and management, including riparian buffers, sediment traps, reforestation, wetland zoning, water management;
- Work together with the lead and supporting agencies, as well as local and provincial stakeholders to ensure an integrated approach to wetland areas, drought and erosion/sediment management that aligns with the 9C-9T Masterplan and Action Plan.

Table 1: Project 5 – Master Plan implementation factors

Item	Description
Alignment to 9C-9T Masterplan	• **Focal Area 2**: Manage urban and rural flood and drought to reduce risk • **Outcome 2.2**: Strengthened rural flood and drought resilience through ecosystem-based planning tools and adaptation interventions • **Output 2.2.2**: Develop spatial zoning and safeguards across rural landscapes, especially relating to existing and new infrastructure, and implement by installing sediment traps, conducting dredging to maintain capacity, maintenance to prevent encroachment of agriculture into reservoir banks, and establishing vegetated buffers along drainage and transport corridors and along allotment boundaries
Implementing stakeholders	• *Lead agency (Cambodia)*: Ministry of Water Resources and Meteorology (MOWRAM) and Ministry of Agriculture, Forestry and Fisheries (MAFF) • *Supporting agency (Cambodia):* Ministry of Environment (MoE) and provincial government
Alignment to agency priorities	MAFF is responsible for governing activities of agriculture, forestry and fisheries and MOWRAM is responsible for governing activities of flood management in the catchment

1.1. Site description

Project 5 covers the Kamping Puoy Reservoir and its catchment. The reservoir is in Banan district of Battambang Province, while part of the catchment area is located in Rotanak Mondol district. The headwater area is slightly hilly with maximum elevations of 300 m above sea level. The rest of the catchment is a low lying plain with scattered villages and small urban settlements. A few vegetated outcrops are situated in the catchment, some in the immediate surrounding of the reservoir.

The dam was built during Khmer Rouge time between 1975 and 1979 where labourers raised the embankment manually. The dam is now a road. The Kamping Puoy reservoir is of particular significance in terms of water resources because it abstracts potentially large volumes from the Stung Mongkol Borey catchment via a major canal offtake upstream of Bavel – the Ou Doun Pov link canal, thereby diverting water resources between catchments. The canal was initially constructed in 2010-2014, with an ADB funded IAIP (Irrigated Agriculture Improvement Project) supporting its further developing from 2021-2023.

The area naturally draining into the reservoir has been fully developed as agricultural land except the few outcrops with steeper slopes and without suitable soil formation. The water consumption for agriculture is high, regularly causing the streams draining to the reservoir to fall dry. The official map of MOWRAM (2019) shows that these streams vanish before they reach the reservoir. The analysis of satellite images confirms this fact. Water abstraction for irrigation is the main cause for the disappearance of the streams. This means that streams from the headwater area do not contribute to inflow into the reservoir which is replenished by surface runoff from the surrounding area only. In other words, the natural catchment has been greatly reduced. As compensation, a 14 km long diversion canal erected at the Mongkol Borey River brings water to the reservoir. The trapezoidal channel faces serious seepage, erosion, sedimentation and evaporation losses.

The Asian Development Bank (ADB) project CAM 51159-002 (2019), *Irrigated Agriculture Improvement Project Kamping Puoy Irrigation Subproject – Battambang Province* yields additional information. According to the project documentation, the project has the following components:

- Lining of 9 km of the 14 km long link canal connecting Mongkol Borey River with the reservoir;
- Rehabilitation of the main irrigation canal including earthworks, 28 distribution and control structures;
- Rehabilitation of secondary irrigation canals; and
- Strengthening of the reservoir embankment of 6.5 km by providing erosion protection on the upstream slope.

The size of the new irrigation command area is 12,000 ha and lies downstream of the reservoir as seen in Figure 1. According to satellite images (Figure 3), the new irrigation command area seems to be in operation.

Figure 1: General layout of the Kamping Puoy Irrigation Subproject[1]

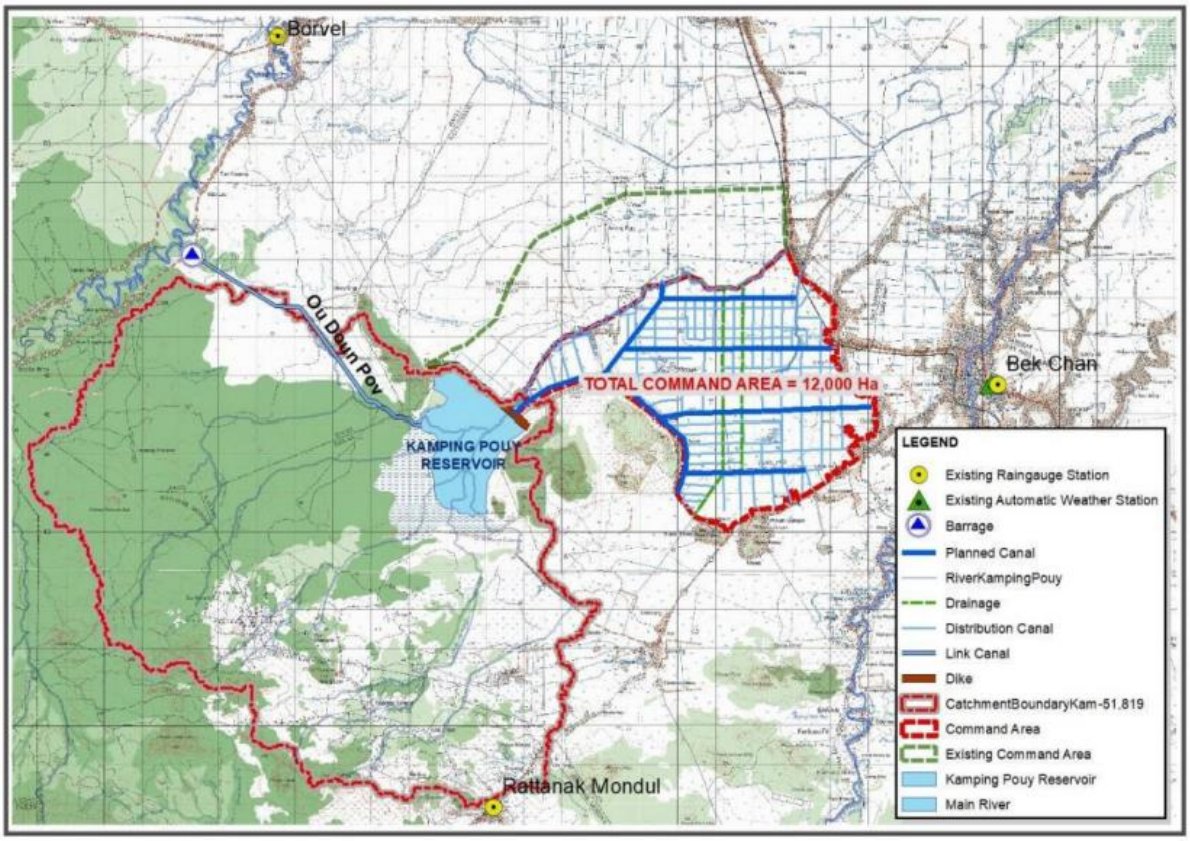
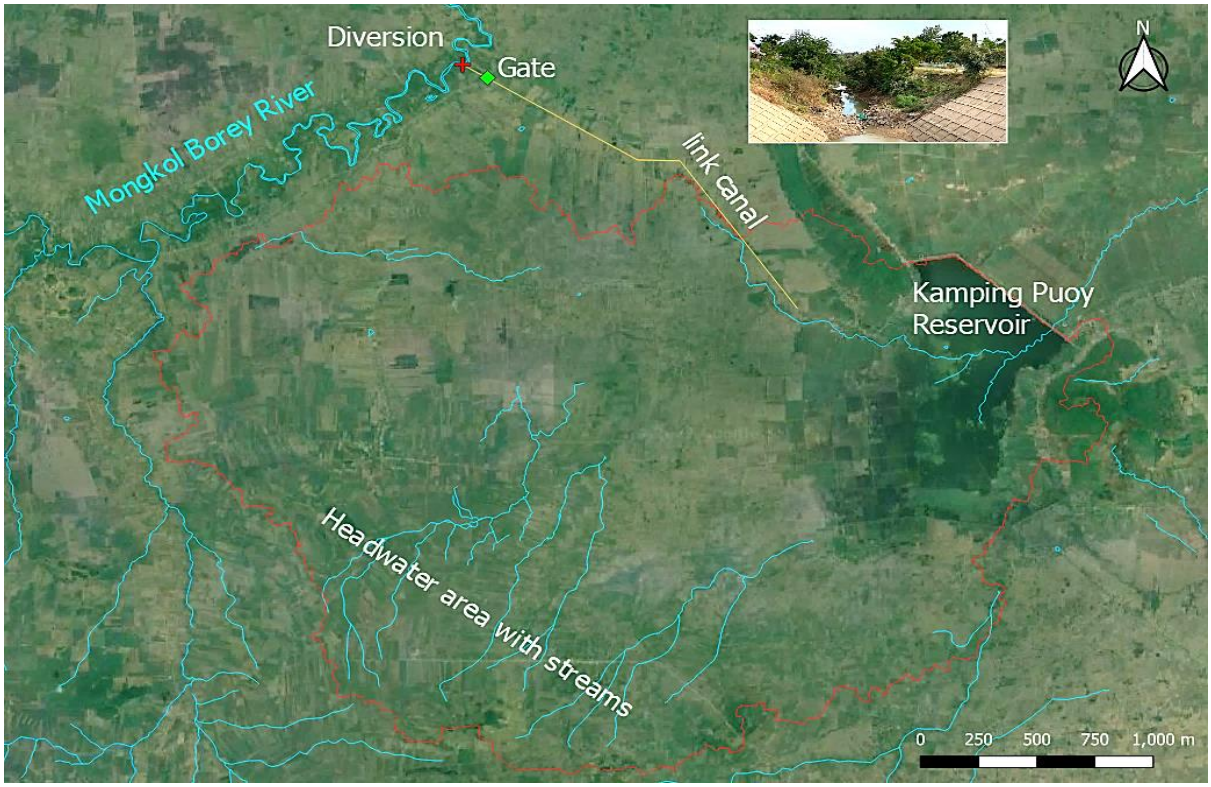


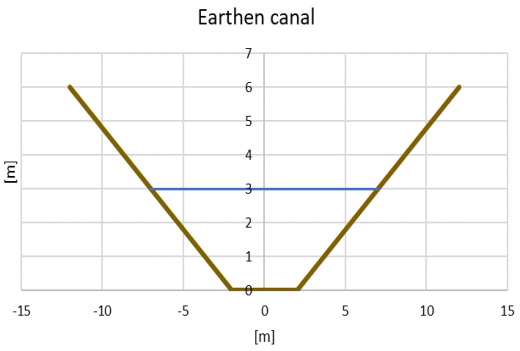
Figure 2 shows the canal 800 m downstream of the diversion close to a regulated gate, which controls the flow in the canal. The estimated geometry is 6m depth, 3 to 4 m at the bottom and maximum of 24 m width at the top.

Figure 2: Canal downstream of the diversion near regulated gate

[1] ADB, 2019: CAM 51159-002 (2019), Irrigated Agriculture Improvement Project, Kamping Puoy Irrigation Subproject – Battambang Province

Figure 3: Catchment area with key hydrological features





With the estimated canal geometry and an assumption of 3 m water depth in the canal, the total volume along the 15 km is approximately 400 000 m^3, which is already a considerable water storage.

With 3 m water depth, the total water surface would be approximately 200 000 m^2. With a daily potential evaporation of 5 mm based on a rather conservative calculation, the daily loss would be approximately 1000 m^3 if the water depth in the canal was 3 m.

The weekly losses would be 7000 m^3 and monthly losses roughly 30 000 m^3. The total loss from evaporation due to operating this canal could be as much as 360,000 m^3 every year depending on the number of days when the canal is filled. Seepage is not counted as losses as the water percolates into the groundwater and is therefore not lost. From an operational point of view, reducing the number of days of operation and if in operation conveying a maximum amount of water seems advantageous to minimise losses. However, there is a disadvantage with such a release policy. The maximum amount of water means high flow velocity and thus high shear stress for both the bed and the banks of the canal. Erosion and hence sediment load will increase and will finally end up in the reservoir. Since the banks of the canal are bare soil and given its length, erosion will be significant.

In conclusion, the canal is an essential part of the water management system of the Kamping Puoy Reservoir and its catchment - it requires rehabilitation attention, as does the reservoir. Assuming that lining according to the ADB project is implemented, rehabilitation of the canal through buffer strips in combination with bank stabilization and measures at the reservoir itself would help prolong the lifetime of the reservoir and dredging intervals of the canal, which in turn yields a direct livelihood and financial benefit. Attention is necessary to design placement of the buffer strips so that dredging is still possible.

1.2. Flood and drought drivers and impacts

1.2.1. Drivers

Lack of integrated water management principles

Water management in this catchment has issues related to cross-sectoral coordination, fair and equitable use of water resources and ecologically sustainably managing water resources in general.

Agriculture, as the main water-dependent sector may need support in practical guidance on how to avoid overexploitation and maintenance of the resource. A possibly unrecognized competition exists between water users located upstream and downstream, which becomes visible only when looking at the entire catchment. Upstream users have direct access to river water and use it to the extent possible within the limits of seasonal availability. Downstream users, however, rely on the supply from the reservoir. Water supply release from the reservoir is fundamentally linked to the downstream interconnected command areas of approximately 19,000 ha.[2] The water related problems arise from fragmentation of the catchment with no integrated management or concern for ecosystem health.

The diversion of water from the Mongkol Borey River expands the problem to another catchment, especially in periods of drought. The potential water use conflicts should be assessed as it will intensify as drought conditions increase due to climate change.

Field interviews with local residents highlighted challenges with flooding and health risks during the rainy season. During the months of September and October extreme runoff discharged from the elevated upstream catchment combined with increased water level in the reservoir results in standing water and inundation surrounding neighbouring villages, such as Andoung Neang village. Flood depths can reach up to 0.7m above the road lasting several weeks.

Encroachment on the reservoir

The field mission and remote sensing revealed that substantial encroachment of the reservoir area takes place during periods of low water levels. When the water level drops, the new land surface is encroached and used for agricultural purposes. The area of the reservoir has shrunk over time. In addition to a possible loss of storage, cultivating crops on areas which might be subject to flooding will transfer organic material, fertilizers and pesticides into the reservoir leading to increased oxygen consumption and eutrophication. The progress over time is illustrated in Figure 4.

Figure 4: Land use encroachment over time at Kamping Puoy Reservoir

02/2017

03/2021

[2] ADB-IAIP ADB Irrigated Agriculture Improvement Project

In 2013, the dam faced a critical situation when the embankment was partly cut to release pressure to avoid an uncontrolled break. In contrast to 2013, the reservoir regularly shows very low water levels where many islands appear and the water surface shrinks considerably. Because of different climate conditions from year to year, the water storage in the Kamping Puoy reservoir varies greatly. During dry spells when the water level is low land is exposed.

1.2.2. Impacts

Based on the results of the field mission and the assessments, the impacts on flood and drought are attributable to the following issues.

Contribution of sediment from the canal – design standard

Given the current design of the canal with unvegetated, eroded banks, it is bringing sediment into the reservoir. More effective management of the canal could help reduce erosion and safeguard the Kamping Puoy Reservoir.

Figure 5: Signs of erosion of canal banks and sedimentation

Loss of water storage in the reservoir

The sediment from the canal settles in the reservoir and reduces its life span. This leads to a reduction in flood mitigation functions and decreases in drought resilience.

Overexploitation of river resources in the catchment

The fact that tributary rivers disappear points to overexploitation and indicates a first-come first-serve water allocation approach in the catchment. The Kamping Puoy Reservoir is a critical water infrastructure asset in the catchment with agriculture as the main water consumer. The current situation calls for a review of water management goals and allocation principles within this catchment in the light of existing inequalities in water use. The foundation problem is the serious and continuing degradation of the watershed.

Health concerns

During periods of excessive flooding, residents report challenges with water pollution, illness, cholera and diarrhoea, because of the standing flood water.

1.3. Concept design of nature based and hybrid solutions

Assuming a full implementation of the ADB project, the link canal is equipped with 9 km of lining and is still an earthen canal for about 5 km. The 9C-9T project needs to address three complementary rehabilitation priorities related to the canal:

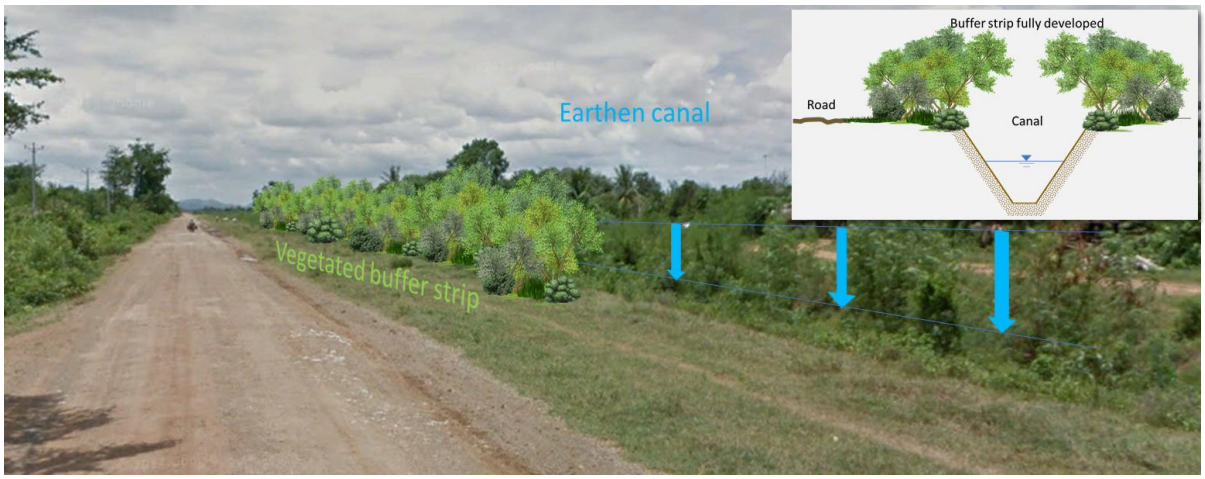
- Development of buffer strips along the canal (Measure 1)
- Sediment traps (see Measure 5)
- Nature-based and hybrid measure to stabilize the canal banks (see Measure 12)

Measure 1: Riparian buffer strip

Using buffer strips along rivers, canals and across agricultural land needs to become standard practice and an essential component of the 9C-9T basin restoration. Buffer strips are measures to retain surface runoff through absorption, plant uptake, deposition and denitrification. By retaining surface runoff, buffer zones reduce the load of sediment, organic matter and nutrients. Trees within the buffer strip can also provide shade and reduce evaporation losses. Figure 6 shows the canal in the catchment approximately one kilometre downstream of the regulated gate. Roads on both sides of the canal are visible following the canal from the gate all the way down to the reservoir. This is an opportunity for NbS application since farming activities are not next to the canal and land ownership problems are less likely. The buffer strips could be developed, interrupted by bridges crossing the canal and considering placement to enable dredging.

A buffer strip either side of the canal is recommended at a width of 15m, in line with good practice design (see Measure 1, Annex 1). Whilst a wider buffer of up to 30m would yield improved habitat provision and sediment and pollution trapping potential, buffer expansion past 15m may prove challenging, due to the need to take from adjacent agricultural land. The establishment and development of the vegetative buffer strip should comprise a mix of native species, to ensure buffer integrity, and maximise ecological health and services.

Figure 6: Buffer strip development along the link canal



Measure 5: Sediment traps

Sediment traps are proposed immediately upstream of the reservoir, near to the inflow channel. The establishment of small multiple functioning sediment traps/pools (through NbS and hybrid structures) offers significant potential within this landscape area. Such interventions would help to collect sediment before it enters the reservoir to prevent sedimentation and decreased water storage capacity.

Figure 7: Potential sediment trap location

Measure 2: Reservoir zoning

The reservoir is steadily diminishing due to encroachment and sedimentation. Boundaries and zones need to be established and enforced. Reservoir zoning is the delineation of a reservoir to its maximum extent defining one or more aquatic zones within this maximum area. The maximum extent is determined by the water level that is associated with the check flood. The check flood is the flood event with a certain return period that the dam must be able to withstand.

An approach to reservoir zoning is therefore proposed below for Kamping Puoy reservoir (Annex 1, Measure 2 for reference). Reservoir zones need to be appropriately defined during later stages with objectives, guidelines and permitted activities:

- A core conservation and recreational zone – established for fish/aquatic habitats and water security;
- An outer sustainable use zone – a seasonal flood area permissible for temporal sustainable agriculture. This is agriculture that adheres to sustainable irrigation practices, without degrading soil quality and using harmful agricultural chemicals.

The variation in the reservoir's extent and volume during the wet and dry season, and associated temporary agricultural encroachment, presents a challenge for implementing zonation. Agriculture is a core livelihood activity surrounding the reservoir and managing water supply and demand along with flood and drought risk is a priority. It is fundamental that local people and communities are suitably acknowledged, engaged and incorporated from the outset of the planning process for this intervention. Agreeing on the zoning and management objectives for each zone (including permissible activities) is an important part of closely involving local communities and other stakeholders in the participatory and sustainable management of the reservoir.

Measure 3: Catchment water management plan

Management of water resources is crucial in conserving ecosystem services. Water management often requires a minimum of controllable infrastructure (e.g. weirs, pumps, gates, and canals) and monitoring. It needs a careful evaluation of water demands, purposes and priorities.

It needs to be a catchment wide approach and integrated water resources management plan. The historic first-come first-serve principle has resulted in imbalances between water users. The construction of the Kamping Puoy was built to store the water from the entire catchment and is now at risk due to the overexploitation upstream. Key water management interventions required include the following (further detailed in Annex 1, Measure 3):

- Regulation and guidelines about sustainable water use associated with Kamping Puoy and its catchment;
- Improvement of water use efficiency associated with Kamping Puoy and its catchment; and
- Hydrological assessment to balance agriculture water consumption upstream and sustainability of the Kamping Puoy reservoir downstream.

A thorough analysis about the current situation, stakeholder analysis, goals, projection of demands are needed to find optimal management rules and a water allocation scheme.

Measure 6: Forest restoration

Opportunities for forest restoration were identified on the steep elevated areas immediately to the east and west of the reservoir. Due to the elevation of these areas, they will require slope stabilisation NbS (see Figure 8 and Measure 6, Annex 1 for example measures).

Figure 8: Example forest restoration, with NbS erosion control

1.3.1. Project benefits

- Canal buffer to retain surface runoff, reduce evaporation losses and reduce the load of sediment, organic matter and nutrients;
- Zoning, regulation and guidelines about sustainable water use and management associated with Kamping Puoy and its catchment;
- Improved water supply and irrigation for the command area of 12,000 ha;
- Restoration and reforestation of degraded elevated areas, to reduce sedimentation and runoff.