UNITED NATIONS ENVIRONMENT PROGRAMME
NAIROBI CONVENTION

WIOSAP FULL PROPOSALS TEMPLATE

Call title: Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities (WIO-SAP)

Participating countries: Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, South Africa, Tanzania [and France (not project beneficiary)]

Executing organization: Nairobi Convention Secretariat

Duration of demo projects: 2 years

Stage of the call: Full proposals

Organisation Name	Universidade Eduardo Mondlane – Faculdade de Engenharia
Project Title	Environmental Flows for enhanced Biodiversity and Poverty alleviation in the Incomati delta, Mozambique (EFlows-Moz)
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Registration Details	Type of organisation: Academic Country: Mozambique Year: 21 August 1963 Registration Number: 500003545

I. BACKGROUND AND JUSTIFICATION

a. The need for Eflows

Different kinds of flows that compose the flow regime of a river will each contribute differently to the river's overall ecological maintenance. The key elements of natural flow regimes are flow variability, low-flows (usually related to dry season), high-flows (associated with floods) and small floods, seasonally and inter-annually distributed. Under unaltered, natural conditions, a river ecosystem persists in a state of dynamic equilibrium, serving the diverse complement of species with different tolerance ranges and different habitat requirements (Brown and King 2002).

Rivers are subject to significant and ever-increasing pressure of alteration leading to the need to conduct environmental flow assessment (EFA) that will guide the implementation of measures that prevent destruction of habitats and important ecosystems.

Environmental flow assessment methodologies have been used in northern hemisphere countries for several decades in order to address environmental aspects of water resource management. A variety of methods is used across the world, ranging from simple empirical methods to more complex ones based on ecosystems functions and values (Acreman and Dunbar 2004).

When applied, they have proved to be an important decision support tool for the management of river flows and have the potential to considerably improve the productivity of river ecosystems (UNEP, 2019).

In the SADC region the experience in implementing environmental flows is limited and has been followed timidly by different countries. Only South Africa and Zimbabwe have mandatory flows for environmental maintenance, although there are several examples of environmental maintenance flows being released (albeit on an ad hoc basis). Following the construction of Cahora Bassa dam in Mozambique, and seeing the changes associated to its flow releases and regime, a proposal was put forward to make flood releases from the dam in mitigation of apparent downstream impacts, including those on the prawn resource in the Zambezi Delta, but due to various reasons these proposals have never been implemented.

The implementation of EFA is also hindered by limited multidisciplinary research platforms within research and education institutions. This is one of the goals of the project, to contribute to the development of a cooperation platform between scientists of different fields and therefore contribute to a capacity building process that is required in order to roll out the process of establishing well founded proposals of Environmental Flow releases for different parts of catchments across the Mozambique.

b. Eflows are a critical issue for Mozambique

In spite of spectacular development progress since independence and considerable GDP growth of on average 7% over the past 2 decades, Mozambique remains one of the world's poorest nations with almost half (46%) of its approximately 30 million people living in absolute poverty. Mozambique's very young population (66% below 25 years of age) is concentrated on the coast (60%) and increasingly urban (32%), especially around the economic hubs of Nacala, Beira and Maputo. Unfortunately, over the past 15 years the economic growth has been increasingly relying on the extractive sector without it translating in an equivalent increase in living standards. The majority of rural population thus remains highly dependent on natural resources and their associated ecosystem services for which rainfall and river flows are key drivers. In most of South-eastern Africa these services have suffered from the prevailing drought conditions affecting the area since 2014, normally associated with ENSO events. In 2019 the country was heavily hit by 2 cyclones. Until recently cyclones with destructive flooding occurred on average at least once per decade but record-breaking climate extremes will likely increase over the next decades even under optimistic scenarios (Nagombe et al. 2018).

Mozambique is a downstream country with most of the catchments of its main rivers (Zambezi, Pungwe, Buzi, Umbeluzi, Limpopo, Incomati, Save and Maputo) originating in upstream neighbouring countries. With its predominantly Tropical Climate, flows are highly seasonal and most transboundary rivers are strongly regulated by storage dams and subject to significant abstraction, mainly for irrigated agriculture. Thus, Mozambique has witnessed a loss of net productivity in many of its estuaries and deltas as more dams, built in upstream countries, became operational reducing freshwater and sediment flows.

In the 1940s the wetlands of Macaneta, in the Marracuene District, Maputo Province, at the mouth of the Incomati River were producing rice from a combination of rainfall and river flooding. In the 1960s the seasonal fishing camp on the coastal sand spit, in this area, became an established village with potable water accessible from the river. The local communities have, since the 1980s, noticed increasing saltwater intrusion up the estuary. Currently, irrigated agriculture is only possible several tens of km upstream. The local users have also noticed erosion of the riverbanks, especially since the 1990s (Bunce et al. 2010). The deltaic wetlands have progressively changed from farmland, to salt-tolerant grasslands (Sporobolus) and reedbeds (Phragmites), to saltmarsh and mangrove and some areas are now devoid of any vegetation because of soil salinization and acidification. Such areas are subject to wind erosion and deflation, interfering with the normal land-building processes that maintain the delta. This enhances the risk for strong and life-threatening erosion events during extreme floods.

The Piggs Peak Agreement of 1991 signed between South Africa, Eswatini and Mozambique established a minimum guaranteed cross border flow of 2 m3 s-1 where the Incomati main stem enter Mozambique from South Africa, but this was not based on any environmental flow assessment. A minimum flow of 20 m3 s-1 to counter the saline intrusion into the estuary was proposed by Hoguane & Antonio (2016). However, a more dynamic and well scheduled release of the environmental flows is probably warranted taking into account the interactions between tides, rainy seasons and river flows. Maputo Bay is characterised by an unusually large spring to neap tide ration (of around 6) that propagates into the Incomati and floods the low-lying areas adjacent to the river (including mangrove, saltmarshes, reedbeds and grasslands) during each spring tide. The water quality of this flooding is especially critical during the equinox tides at the end of dry season when the river is in spate (September - October). Such detrimental high salinity flooding might be countered by establishing pulsed environmental flow protocols as suggested by Sengo et al. 2005.

The Macaneta wetlands are used by a range of stakeholders that practice fisheries, agriculture (mainly rainfed at the edges of the dunes), free-range livestock keeping and the gathering of a variety of natural resources (e.g. reeds, wood for energy and construction, wild fruits, etc). The fisheries can be both marine and estuarine according to the season and are using a variety of crafts and nets and target both fish and marine invertebrates. Some of these are collected on foot (crabs, shrimp, gastropods) both for consumption and to be used as bait. It is estimated that around

20% of the 200 tonnes of shrimp fished in Maputo Bay derive from the Lower Incomati and healthy mangrove systems are a vital element in this productivity. Similarly, saltmarshes are important feeding areas for juvenile fish. Furthermore, since the construction of the new road bridge across the Incomati River, the flow of tourists into the Macaneta area, for daily or weekly periods, has increased dramatically. This is accompanied by an increased building of new lodges and housing that are inevitably tapping into the groundwater resources of the floodplain and dunes. Due to on-going drought situation (since 2014) in the southern part of Mozambique the Pequenos Limbobos dam in the Umbeluzi river is not able to adequately supply the great Maputo urban area. This led to the development of a new well-field, to tap the important groundwater system adjacent to Incomati river, to augment supply to Maputo city. A clear assessment of the groundwater resources and the impacts of increased salinity in the river water on this resource is not yet established.

Considering that currently around 50% of the water from the entire Incomati Basin is abstracted upstream, mainly for irrigation, the increasing abstraction of groundwater resources in the aquifer system adjacent to the Incomati river, that the climate trends in South-eastern Africa point to a decrease in rainfall and that more dams are planned or under construction it is clear that the pristine pre-dam (say 1950) conditions cannot be re-established. Still, realistic scenarios of increased freshwater flows that can improve the functioning of key species and species groups (e.g. the mangrove, the saltmarshes, the reedbeds and the grasslands) within the system can be proposed. Such flows have the potential of improving the well-being livelihoods of vulnerable users in the system (fishers, livestock keepers, gatherers of wild plants e.g. reeds, etc.).

It is the hypothesis of this proposal that (1) pulsed flows would be better adapted to the dynamic tidal environment of the Lower Incomati than the application of minimal flows as agreed between the countries in the basin or proposed by previous studies and that (2) potentially more can be achieved with less or equivalent amounts of water by optimising the timing of the releases with the tidal and seasonal rain rhythms.

c. Relation to other relevant national development strategies and policies; WIOSAP priorities and relevant global commitments

Presently, ARA-Sul in Mozambique makes water releases for environmental purposes from all of its dams, although these are not based on comprehensive determinations of the environmental requirements and equate more to minimum flows. As part of the project for the rehabilitation of the Massingir Dam on the Elephants River a study was carried out for EFA with environmental flows to be incorporated into the operating rules of the dam subsequent to finalisation of the rehabilitation works. Two sites were investigated in the downstream part of the river however, the proposed regime has not yet been adopted.

Mozambique enacted its Water Law in 1991, based on this law a National Water Policy was introduced in 1995, revised in 2007 to Water Policy and revised in 2016 to align with the evolution in the water sector. While the Water Law of 1991 is somehow vague in terms of promoting environmental flows some elements of protection of water resources can be found when provisions are made for protection of water quality of rivers and prevent degradation of water resources. The water policy is more assuring and calls for specific actions in ensuring Water for Environmental Conservation across the country especially in shared transboundary water systems. Chapter 4 of the Policy is dedicated to 'Water and the Environment' and the policy states the following objectives "ensure that water resources development and management take full account of the need for environmental conservation, with adequate water supply both in quantity and quality for environmental sustainability." Related to conservation the goal of the national policy is to set ecological flows for rivers and estuaries, water quality standards for effluent discharges and receiving bodies of water, and measures for pollution prevention and mitigation of their effects.

Mozambique is part of the Southern Africa Development Community (SADC) that is geared towards promoting social and economic development of the region based on values of peace and cooperation among States. SADC initially passed its Protocol on Shared Watercourses on 28th August 1995, which was revised on 7th August 2000. The Protocol aims to foster closer cooperation among Member States for protection, management, and use of shared watercourses in the region. The revision was necessary in order to take into account concerns raised by Mozambique and other downstream countries regarding some aspects of the original Treaty but also in order to include other emerging aspects following the introduction in 1997 of the UN Convention on the Law of Non-navigational Uses of International Watercourses. This shows that Mozambique and the regional riparian countries have been following closely the developments in the international arena in what relates to sustainable development and protection of the environment. Mozambique is also part of the regional coalition of the Western Indian Ocean countries working to protect and promote sustainable utilization of the vast coastal and maritime resources in the region. The countries of the region have agreed that concerted conservation interventions by all members are needed in order to curb degradation associated to land-based sources and activities and protect the critical coastal and marine ecosystems, mainly mangroves, seagrass beds, estuaries/rivers and coral reefs that are so critical to the well-being of the coastal population but also to the economies of the countries.

The WIOSAP programme 'Implementation of the Strategic Action Programme for the protection of the Western Indian Ocean from land-based sources and activities' is intended 'to reduce impacts from land-based sources and activities and sustainably manage critical coastal and marine ecosystems through the implementation of the agreed WIOSAP priorities with the support of partnerships at national and regional levels'.
The current proposal is therefore a contribution to the efforts being made by Mozambique in order to implement concrete actions that will restore vital ecosystems affected by the current water management practices in the country but also by the global changes such as climate, accelerated population increase and urbanization. This project is also linked to the on-going initiative by the National Directorate of Water Resources Management in Mozambique to roll out a Compliance Monitoring Strategy of the Shared Watercourses.
The WIOSAP initiative has also developed an Environmental Flow Assessment (EFA) guideline that discussed in greater details the various options of methods for conducting EFA (UNEP, 2019). In implementing this study, the guideline will be followed closely as a reference for the work to be carried out by the research team. As stated in the guideline, the choice of method to be used can be affected by the availability of information on the key aspects of hydrology, hydraulics of the system, water quality, sediments and geomorphology, biology and social but it is our endeavour to adopt an **holistic and scenario-based approach.**

d. other programmes complementing the proposal
The UEM team has a long time experience in hydraulic modelling, hydrological assessment and eflows design. The proponent (UEM) together with its partners (IRD and IHE) are part of the WIODER- West Indian Ocean Deltas Exchange and Research Network (funded by the IDRC and IRD) which aims at studying the dynamics of the deltas on the Indian Ocean region (www.wioder.org) and especially at assessing the impact of dams on deltas and the possibility of dam re-operation to allow eflows. The E-flow project will benefit from the hydrological results and experience of the team. This Eflow proposal is designed in a way that it will benefit from synergies and results that the team will obtain from other projects it is involved. This will lead to rationalization of funds but also increase the impact and outreach of the project specially in relation to capacity building and police advocacy.
Having this in mind, in addition to the interactions with other aspects within the WIODER network, funds from a FFEM (French Fund for the Global Environment) project "Science-Decision-makers Dialogue for an Integrated Marine and Coastal Environment Management (DiDEM)", to which IRD, UEM and IHE are participating, will be dedicated to support a relevant communication process between the scientific team and the decision-makers at the local, national and regional level (policy briefs, field visits, workshops) and dialog with the civil society (public conference, activities with the schools, tourist operators and environmentalists groups).

II. PARTNERSHIPS

Partner Name	Mandate	Role in the project	Resources
UEM	Mozambican Academic institution (Faculty of Engineering)	Hydrological analysis of the incomati River Flood extension mapping with Drone River morphodynamical analysis Water quality analysis and mapping Analysis of the dams management scenarios	• Experience on hydrological analysis (quantity and quality) • Drones (2) and experience on mapping with drones • 2 scientists (Dinis Juizo, Elidio Massunghane), 3 junior researchers and 2 lab technicians • 2 MSc. Students engaged in the project for their thesis.
UEM	Mozambican Academic institution (Department of Biological Science)	Fish Biology and Ecology Mangrove ecology	• 2 scientists (Adriano Macia, Mangrove specialist (To be named), 2 junior researchers (Vilma Machava, 1 junior to be named) • 1 M.Sc. Student engaged in the project for his thesis.
ARA-Sul	Public Institution in charge of Water Management in Incomati and Limpopo basins.	• Participate in river flow monitoring • Provide climatic data for the project	• Provide technicians to support the implementation of the project • Participate in steering committee of the project.

IRD (Institute of Research for Development) UMR PALOC	French public research Institute dedicated to research and capacity building in Africa, Asia and Latin America (www.ird.fr). The UMR Paloc, based at the National Museum in France support participatory research	• Support the development of citizen science through the setting-up of participatory observatories • Mapping of land-uses • Deltaic Ecosystem services analysis • Social interviews with the local stakeholders	• 2 scientists at 20% of their time (in kind contribution): Stéphanie Duvail, Raphaëlle Ducrot) • Experience on participatory research and setting-up of local observatories of the environment (Tana River delta in Kenya and Rufiji River delta in Tanzania) • Through the IT department of the IRD and MNHN, support the design of a specific app for the communication within the network • Master grants for Mozambican students • PhD grants through competitive call
IHE-Delft	Dutch Academic institution	• Support in the development of the drone image analysis methodology • Participate in field data collection • Implement the GIS mapping.	• 1 scientist, specialized in drone operation and GIS mapping (Paolo Paron). • Recruit and supervise 2 M.Sc. Students for the project.
4 Municipalities along the Incomati	Local government	• Support of the process and implementation of the results	• Teams in the 4 municipalities
Consultants	One international Consultant –Olivier Hamerlynck One Local Consultant	• Oliver is a senior ecologist with strong knowledge of the interactions between in-land and marine systems (Fish ecology, Bird ecology) • 1 junior consultant (preferably botanist)	• 1 senior consultant • 1 junior consultant

III. OBJECTIVES

A. Overall objective

The purpose (overall objective) of the project is to design environmental flows that would maintain and enhance biodiversity values and the functioning of the estuarine and deltaic ecosystems of the Lower Incomati in order to optimise the delivery of a number of key ecosystem services to a range of stakeholders and with the well-being of vulnerable user groups a priority. The project is seen as an implementation and testing of the EFA guidelines, and their adaptation to the Mozambican context. Hence, the experiences and results will allow Mozambique to contribute with ideas and proposals for further development of typical methodologies for eflows implementation by the WIO countries. It will also contribute to fostering of multidisciplinary team working to interface natural and social sciences.

B. Immediate/specific objectives

1 - Constitution of a multi-disciplinary, multi-institutional and participatory research team for observation, monitoring, analysis and eflow scenario-development

Expected effects for beneficiaries: Inclusion of the local users and local decision-makers in the definition, monitoring and result analysis

2 - Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years

Expected effects for beneficiaries: Improved knowledge of the habitat dynamics and insight on the processes at work for the decision-makers and technicians at the local level (municipalities) and national level (ANAC, ARA-SUL, Ministry of Environment)

3 - Analysis of the current freshwater flow pattern (as a driving indicator): the aim is to analyse the quantity, quality and the spatial extent of the freshwater entering the key habitats of the Macaneta wetlands in the Lower Incomati (and their interaction with the tidal rythms)
4 - Identification and quantification of the relationships between the freshwater flow pattern and the coastal wetland productivity using biological proxies (plants, fish, birds) – Ecological indicators
5 – Ecosystem services analysis including a semi-quantitative analysis of links between the natural resource produced by the delta and the user livelihoods, at the household level and comprehensive analysis of the stakeholders' natural resource use strategies (including the policy context) and their interactions, tensions and trade-offs
Expected effects for beneficiaries: Analysis of the stakeholder's specific strategies can help identify the constraints and ease reaching a consensus on the wetland management
6 – Jointly develop and discuss Eflow scenarios that could optimize the wetland productivity, meet the downstream user needs and strategies and alleviate poverty
Expected effects for beneficiaries: Improved ecological integrity and poverty alleviation of the Incomati delta

IV. PROJECT IMPLEMENTATION AND MANAGEMENT PLAN (See definitions in Annex 3)

A. Expected project results and indicators

The table below summarizes the expected results, outputs and indicators of this study.

Objective	Expected Results	Outcomes/outputs	Indicators
1 - Constitution of a multi-disciplinary, multi-institutional and participatory research team for observation, monitoring, analysis and Eflow scenario-development	Opening of a communication channel between the various stakeholders that can help building shared knowledge and common understanding of the hydro-ecological processes at work	• Participatory observatory of the Macaneta wetland environment is in place. • Jointly designed Eflow methodology and collective result discussions • Report detailing the assessment of methods applied in eflow determination with key recommendations • Website	• A logical framework for the project implementation and evaluation is developed and approved • Regular multi-disciplinary and multi institutional meetings (At least 1 every 6 months).
2 - Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their changes in the past 70 years	Current spatial extent of the key habitat and understanding of the processes at work over the years (key habitats extension trends, but also agriculture development, salinization, urban and tourism development etc.)	• Map of the current land uses, with special emphasis of key habitat and their biodiversity value. Diachronic maps • 2 Master thesis	• Map production • Nr of students involved in the project and finalizing their thesis.
3 - Analysis of the current freshwater flow pattern (as a driving indicator)	Analysis of the quantity, quality and the spatial extent of the freshwater entering the key habitats of the Macaneta wetlands in the Lower Incomati (and their interaction with the salty water)	• Hydrological model of the Incomati River basin. Dynamic model of the flooded areas (through the year, linked to water level at the delta entrance and tidal influence at the estuary). • 2 MSc Thesis	• Regular monitoring of the flows, • Development of a dynamic model • Nr of students involved in the project and finalizing their thesis.
4 - Identification and quantification of the	Link between the flood pulse and biological	Definition of the environmental freshwater	Monitoring of Ecological indicators

relationships between the freshwater flow pattern and the coastal wetland productivity	proxies (plants, fish, birds)	needs	
5 – Ecosystem services and Comprehensive analysis of the stakeholders' natural resource use strategies (including the policy context) and their interactions	• semi-quantitative analysis of links between the natural resource produced by the delta and the livelihoods at the household level of the users. • Description of the current natural resource management strategies and evaluation of tensions •	• - Economic valuation of key resources (fisheries, agriculture, livestock, collection of wild plants and animals, tourism, etc.) • Analytical report	• Number of Resource user strategies described • Number of semi directive interviews conducted • Resources evaluated • Number of households assessed
6 - Develop Eflow scenarios that can optimize the wetland productivity, meet the downstream user needs and alleviate poverty	A set of scenarios and their estimated impacts on the biodiversity, ecosystem services and the local economy	Eflows recommendations jointly produced	• Number of participatory workshops • Inclusion of the key stakeholders

B. Project activities and work plan

1- Constitution of a multi-disciplinary and participatory research team- Outcome Leader: Olivier Hamerlynck

The project aims at putting in place a participatory research framework where the observation, measurement, data analysis and recommendations are jointly made by expert scientists, managers and local users. This team will be composed of scientists from the University Eduardo Mondlane and its partners (IRD and IHE-Delft), of technical staff of the water and environment administration, of the local government and of delta stakeholders (delta local users, tourist operators, protected area managers). This team stems from already existing joint activities of the team's partner. Through field visits and classroom interactions the issue at hand will be described and the concept of environmental flows explored in detail. These are the major steps envisaged for this project: (1) the existing knowledge on the lower Incomati will be analysed and synthetised, (2) knowledge gaps identified (3) choices for the components to be analysed discussed on the basis of efficiency criteria (feasibility, cost, assessment of its role in the ecosystem and user value, etc.). Natural indicators on which we will focus are for the implementation of participatory research are: (A) the mangroves (health assessment), the reedbeds, fisheries monitoring, waterbirds (easy to monitor, counted); (B) flow measurements at the entrance of the estuary will be recorded with dataloggers but a network of water levels local observer can also be put in place; (C) Salinity is central in monitoring of the environmental conditions and it will be measured in flowing and stagnant waters, boreholes, where possible, in different habitats and during different river stages (flood – spate) and tidal conditions (spring neap cycle, equinox tides).

Once the joint design of the approach and research protocol is prepared and implemented, regular feedback sessions on the findings are organised. From the results of the discussions, proposals for optimum flood releases are prepared.

2 – Mapping and Change detection of the wetland. Outcome Leader: Paolo Paron (IHE)

Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years. The work will be carried out through re-interpretation of existing cartographic information to be acquired at the National Cartography Center combined with satellite imaginary acquired over time and representing different periods of development of the Macaneta area. Aerial photographs at adequate scale will be included in the analysis. Paleo channel analysis will be carried out in order to identify the most predominant channels and morphological changes on the river in the area. Field surveys will be implemented to study the historic sediment depositional environment in the most interesting areas of the study.

3 – Hydrological assessment. Outcome Leader: Dinis Juizo (UEM)

Analysis of the current freshwater flow pattern (as a driving indicator): we aim at analysing the quantity, quality and the spatial extent of the freshwater entering the key habitats of the Macaneta wetlands in the Lower Incomati (and their interaction with the salty water)

Detailed activities include:

- mapping of the floods frequency in the Incomati lower floodplains and deltas over a period of 24 months (in order to capture several flood events): For this we will use the hydrological data already collected by the team, to be complemented by some detailed descriptions of the flood extent and duration acquired by the use of satellite image and drone images combined with water level and salinity information (both collected by automatic dataloggers and water-level recorded by local observers).
- Development of a floodplain elevation model using STRM and Drone mapping, to be complemented by precise river bed profiles (from Bathymetry)
- In conjunction with activity 2 of the project, build a comprehensive peleaochannel analysis of the lower Incomati flood plain and explain the evolution and channel interconnectivity over time
- Monitoring of the fresh water flow at the delta entrance: Install a staff gauge at the delta entrance (to be recorded daily by local observer) + automatic OTT Doppler flow and salinity recorder
- Monitoring of the water levels and salinity at several points in the delta
- Satellite images of the maximum flood extent for several years -Sentinel and Modis
- Analysis of the surface/ground water interactions in the surrounding dunes
- Delta Modelling
- Water balance analysis and comments on the critical seasons for the delta hydrology

4 – Links hydrology-ecology Outcome leader: Adriano Macia (UEM)

Identification and quantification of the relationships between the freshwater flow pattern and the coastal wetland productivity using biological proxies (plants, fish, birds) – Ecological indicators:

- Crabs and macroinvertebrates: estimation of the physiological range for crabs and chironomids – midges
- Fish: estimation of the physiological range for fish
- Birds: Regular birds survey and mapping, analysis of their density through time as a proxy for the nutritional quality of the water
- - Mangrove Detailed mangrove mapping, using drone, estimation of the physiological range for mangrove species
- Floodplain vegetation, Detailed vegetation mapping, using drone

5 - Comprehensive analysis of the stakeholders' natural resource use strategies (including the policy context) and their interactions, Outcome Leader: Stéphanie Duvail (IRD)

- Mapping and analysis of the local uses of the deltaic resource (mapping of the fishing, agriculture, grass and weed collection zones and estimation of their economic level using interview and participatory mapping) and the access rules and governance of the deltaic natural resource
- Typology of the main wetland user livelihood profiles and detailed analysis of the water requirement of the traditional farming systems
- Quantitative Socio economic household survey of a number of families (following the user profile predefined)
- Economic valuation of the ecosystem services of the wetland Review of the (historical) land tenure systems and mapping of spatial planning and projects for the zone
- National e-flow policy context and stakeholder mapping and international constraints of the dam management

6 – Eflow scenarios development. Outcome Leader: Elidio Massuanganhe and Dinis Juizo (UEM)

- Develop Eflow scenarios that can optimize the wetland productivity, meet the downstream user needs and alleviate poverty
- Integration of the various water needs and constraints
- Definition of critical scenarios and ideal scenarios (that would maximise the benefits for the ecosystems and users)

C. Project Beneficiaries

This project tackles an issue that has implications at regional and national scale, in this case the project will have multiple beneficiaries.

Direct beneficiaries:

(i) Local user communities. Fishers, livestock keepers, farmers, gatherers: they will be involved in the project design from the beginning through the set-up of an participatory observatory. Several local observers will be designated.

(ii) Researchers and students. The project will involve 10 people from UEM, with a special emphasis on capacity-building for young researchers and up to 3 from IRD and IHE-Delft (through a co-funding mechanism).

(iii) Municipality and Government representatives. These stakeholders will benefit from having a much clearer and quantitative assessment of the water resources available and its quality at different times of the year and their associated biodiversity and economic values. This increased knowledge will help in planning the uses of water and other natural resources in an economically sustainable way. They will benefit by having a new set of methods to monitor eflows and being able to plan for management interventions to promote the sustainable use of the natural resources.

(iv) Local businesses and Society in general.

Implementation of Eflows that lead to an healthier and more productive delta is an added value for the tourism operators and the Maputo urban population that visit Macaneta for the week-end. Schools will benefit from knowledge sharing.

Project design: During the project design there was a consultation with the various beneficiaries and their contribution was captured in the project set-up. Furthermore one of the first activities of the project involves a wider stakeholders meeting that will provide an opportunity to further fine-tune the approach proposed in particular regarding the participatory monitoring component of the study.

Gender considerations: The team is gender-balanced among the scientists. In Incomati the majority of people working along the river margins are farmers and gender is well balanced among them. In this project we will seek to have a balance in the participation of local stakeholders.

D. Implementing agency management of project

The project will be coordinated by the Faculty of Engineering at the Eduardo Mondlane University (UEM). The project will have a scientific steering committee composed of representatives of the three main research entities namely UEM, IRD and IHE. The UEM team will be responsible for coordinating the fieldwork activities (use of drones, hydro-ecological assessment and installation of monitoring equipment, flood extent analysis, river geomorphological studies), liaising with local entities and stakeholders that will participate in the study and coordinate the preparation of the various reports of the project. The IRD team, together with Mozambican social scientists from other department of the UEM, will support the design of the participatory monitoring component of the study, of the ecosystem services assessment and the household survey. The IHE team will implement the drone image analysis, process images and GIS mapping including mapping and change detection of the wetlands and its uses with support from UEM. The ecological analysis will be provided by the expertise of Olivier Hamerlynck together with Mozambican ecologists from other department of the UEM. Apart from these core scientific partners there are other partners that will participate in the project. ARA-Sul will participate in river flow monitoring and will provide data to be used in flood extent mapping. The local users will be involved in the monitoring of water and key resources and in the result analysis. The Municipalities, national environmental agencies (such as ANAC) and private tourists operators will be involved in the interpretation of results and raising awareness about the sustainable use of hydro-ecological services. All together the scientific and stakeholders partners of the project will design the optimal Eflow recommendations for the Incomati River Delta Sustainable use.

V. PROJECT METHODOLOGY

Outcome 1: Constitution of a multi-disciplinary, multi-institutional and participatory research team

The research project will build on the experience of some of its team member in implementing similar task in Tanzania and Kenya involving the development of participatory environmental observatories (Duvail et al. 2014, Duvail et al. 2018). In this approach local observers are involved in the monitoring of water, rainfall, fish, birds, vegetation (etc.) using simple protocols, co-developed in an interactive process. The results are regularly synthetized, analysed and discussed collectively. This help building a consensus on the functioning of the wetland. The core research team of the project was setup during the preparation of the project and covers the key components related to the functioning of the system i.e hydrology, social sciences, biology and ecology but it also includes fundamental disciplines that are of particular relevance to the Incomati river e.g. river morphodynamics and mangroves. Other disciplines will eventually be necessary in order to help the team address particular aspects such as the economics but these will be mobilized on a needs basis in form of consultancies of through interaction with other researchers within the respective members of the consortium. Some references linked to the methodology to be followed are given below.

Duvail S., Mwakalinga A. B., Eijkelenburg A., Hamerlynck O., Kindinda K. et Majule A. 2013. « Jointly thinking the post-dam future: exchange of local and scientific knowledge on the lakes of the Lower Rufiji, Tanzania », Hydrological Sciences Journal, 59(3-4), p. 713-730

Duvail S., Paul J. L., Hamerlynck O., Majule A., Nyingi W.D., Mwakalinga A. Kindinda K ., 2018. Recherches participatives en Tanzanie : un observatoire local pour un dialogue autour de la gestion des territoires et de l'eau ». Natures, Sciences, Sociétés, 25 (4), 347-359.

Outcome 2: Mapping and change detection of wetland

Comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years. During this activity we will focus on the whole Incomati basin, including its part in South Africa and Eswatini. This is important due to the transboundary nature of the basin and to the different developments in land cover and land use that have occurred in the past decades across the entire basin in different fashions. Using freely available remote sensing data and where available historical aerial photography we will map the following aspects, for as back in time as possible:

1. **Terrain and Geomorphology** (analysing data from the Shuttle Radar Topography Mission –SRTM at 30 m of resolution, and other sources where available)
2. **Geology** (adapting data from National Geological Surveys and from the globally available OneGeology project);
3. **Soil type** (adapting data from the Global Soil Map of the World) and Soil Moisture (analysing data from Soil Moisture Active Passive (SMAP) and from other sources);
4. **Precipitation seasonality and intensity** (analysing data from NASA Global Precipitation Model (GPM), Topical Rainfall Measuring Mission (TRMM), Rainfall Estimate (RFE), and others);
5. **Flooding extent, patterns and frequency** (analysing data from MODIS, Landsat and Sentinel sensors);
6. **Land cover** with a special focus on forest, grassland, agriculture and mangroves, and soil and coastal erosion (analysing both visible and NDVI data from historical aerial photography, Landsat, Aster, and Sentinel sensors);
7. **Human settlement** (analysing data from day time and night time Landsat and Sentinel data as well as historical aerial photo where available);
8. **Human population density** (analysing data from the global gridded population of the world).

For each of the above parameter we will determine maximum and minimum values as well as average, seasonality and its shifts in time over the time period analysed. We will be able to define trends over time and critical moments of drastic changes. Every time possible we will also compare this remote sensing data with ground observation to validate the remote sensing analyses. This will be mostly relevant for the precipitation and land cover data.

We will make use of a combination of tools to analyse these datasets. On one hand we will use semiautomatic methods and algorithm available in Google Earth Engine (GEE), with the advantage of having all the freely available data at hand without the need to download them on a computer, and also the advantage of using the power of distributed computing of Google servers. On the other hand we will make use of Object Based Image Analyses (OBIA) for extracting meaningful information from the historical aerial photography and from the drone images where available. The GEE analyses will provide time series of thousands of remote sensing scenes. The historical aerial photo and drone OBIA analyses will allow us to extract higher resolution detail and also to complement the time series generate with GEE. In this way we aim at expanding the creation of a mapping baseline starting from the early 1960s (historical aerial photo) up to present. During the initial phases of the project the team will research of availability of remotely sensed data on Human population density in order to produce chronological maps that will inform about the changes in human pressure on the environment of the upper catchment but also around the specific study area.

Outcome 3.0 Hydrological assessment

We will carry out data collection and analysis to study the past river flow regime of the Incomati and identify the most relevant aspects of the flow regime by applying statistics. The Incomati river has adequate hydrometeorological network and relatively robust time series in relation to the length but also continuity of data observations. Discharge data of most river might present gaps due to various reasons among which non-operational gauging stations resulting from destructions during flood events. If gaps are found in the hydrological data and are considered worth of treatment, appropriate methods will be used to correct this deficiency e.g. rainfall-runoff modelling for discharge data, statistical infilling of rainfall data or use of satellite derived rainfall for precipitation data. Overall remote sensed data will be used as much as possible as source of hydrometeorological data for the project. Na hydrodynamic model of the lower Incomati encompassing the area of interests for the movement of the water in the Lower Incomati will be built. HEC-RAS is the chosen modelling platform to create a full 2D model of the flood plain to be fed by the hydrometeorological data described before. A terrain model generated under outcome 2 will also be used to build the model of this study. HEC-RAS capabilities includes the simulation of river hydraulics and sediment transport, computation of river velocities, stages, profiles, and inundated areas. There is one-dimensional (1D) water quality capabilities that has been developed and is being extended to simulate water quality in river reaches. These capabilities responds well to the need of the project as it will enable the team to map the impacts of different scenarios of river development and associated flow regimes as well as the water quality implications in the system. If necessary the team is able to use more advanced modelling software such as the Delft3D-WAQ that as 1D/2D/3D options for water quality modelling.

Outcome 4.0 Hydro-ecology

The interactions between the biota (Fish, Birds and the vegetation) and the hydrological conditions are described (see Hamerlynck et al. 2011 for the fish). For each chosen ecological proxy, a detailed analysis is provided on the hydrological conditions that would maximise the productivity. Similar approach was used successfully by the team as described in:

Hamerlynck, O., Duvail, S., Vandepitte, L., Kindinda, K., Nyingi, D. W., Paul, J.-L., Yanda, P.Z., Mwakalinga, A.B., Mgaya, Y.D. & Snoeks J. 2011. To connect or not to connect – floods, fisheries and livelihoods in the Lower Rufiji floodplain lakes, Tanzania. Hydrological Sciences Journal 56 (8): 1436-1451.

Outcome 5.0 : Comprehensive analysis of the stakeholders' natural resource use strategies (including the policy context) and their interactions .

A ecosystem service evaluation is first developed at the scale of the whole ecosystem. In a second step, a stakeholders mapping exercise is conducted in order to define a typology of the resource users. Some representative households are chosen and household surveys are conducted for quantification purpose. Detailed water requirements are defined at the user level and tensions and synergies between water needs are described.

Outcome 6.0 Eflows scenarios development.

A baseline and future scenarios regarding the water and land use policy, governance and management for the Incomati basin is sought. One of the goals of the project is to propose a water use and management scenario that will be compatible with the objectives of maintaining a healthy functioning and productive ecosystem in downstream of Incomati. Existing data on the biophysical and socio-economic current situation and trends of the basins and on the applied and applicable legal and policy frameworks and their existing and prospective impacts on riparian States and society will be compiled and analysed. The development of future plausible pathways will be done following a consultative process with different stakeholders across the basin, based on a combination of these individual objectives to be tested in a water allocation model. There is a variety of tools available in this case the team will use the Water Evaluation and Planning (WEAP21) developed by the Stockholm Environment Institute's U.S. Center. This a practical and easy to use tool that enables the analysis of complex problems of water allocation in river basins. The team will focus on the following sub-objectives in this task:

1) definition of the pathways to be evaluated in the model;
2) definition of evaluation indicators that will be used to assess the different outcomes;
3) selection of efficient pathways via optimization under baseline and future scenarios.

During the implementation of the project a protocol will be developed for the testing of the proposed management option that allows the establishment of E-Flows in the Incomati. This will take into account the time needed for the proposed regime to yield results in the system. The duration of the project might not be enough to allow the team to observe the outcomes of any river flows prescription that might be developed in this project but efforts will be maybe to produce clear guideline for future monitoring of actions that need to be taken to ensure the goals of the Eflows are met.

VI. SUSTAINABILITY AND REPLICABILITY

In the long run it is expected that the techniques developed in this study will be mainstreamed into a government action plan enabling it to actively engage in designing additional Eflow proposals for other rivers. The method being proposed can be replicated easily to other river basins with relatively limited investment. Mozambique is signatory to the global agenda for sustainable development and has made commitments to monitor the key indicators over the various SDGs. However, the lack of appropriate tools and methodology is a major obstacle in producing the required data and information. This project through the design of a methodology aligned with the WIOSAP EFlow guidelines and adapted to the Mozambican context will be a major improvement.

VII. PROJECT MONITORING AND EVALUATION

To facilitate the implementation of the project a core management group will be created composed of all partner´s representatives. This PMG (Project Management Group); will host regular skype meeting every month, to discuss plan and implement activities.

The PMG will be chaired by the UEM representative in the project and supported by the representative of IRD. The discussion of the PMG will be structured in a logical framework with clear identification of the actions proposed, results, responsible people, resources needed to meet a specific objective of the project. This tool will enable progress monitoring and identification of main bottlenecks in implementation.

Each PMG meeting will be registered, minutes taken and kept for distribution. A web page of project will be maintained. A 2-3 days seminar kick off and final workshop are envisaged in the project.

The project will hire an assistant with a prime role to keep track of the PMG and ensure regular communications with all participants of the project. Project activities will be regularly communicated to a wider audience from university web page and information bulletin.

VIII. BUDGET

A detailed budget and justification is presented in the attached Table. We propose a total budget of US$ 199,649.00 (One hundred ninety nine thousand six hundred forty nine American dollars) in addition to US$ 127 853 (one hundred and twenty seven thousand eight hundred fifty three American dollars) of co-funding. The co-funding is composed as follow:

UEM will provide office space and other offices support for the project team, will make available a field vehicle for the use by the project, basic salaries, this contribution will total US$ 12 000 (7000 USD in salaries and 5000 USD in Operations costs), over the course of implementation of the project. IRD will provide in-kind contribution totalling US$ 38 850, related to IRD staff salaries and finally IHE will also provide in-kind contribution totalling US$ 3 000.

In addition to the co-funding provided by the three partners UEM, IRD, and IHE, the project will benefit from complementary external co-funding through the DIDEM ("Science-Decision-makers Dialogue for an Integrated Marine and Coastal Environment Management") project dedicated to help improving the information flow between Science and Policy in the Indian Ocean. In the DIDEM a budget of 74003 USD (app. 66 750 EUR) is specifically dedicated to fieldwork in the Incomati delta (especially Land-Use cartography in support of Output 3, analysis of stakeholders' strategy in support of output 5 and organisation of workshops for all stakeholders in support of ouput 1 and 6).

Project workplan

Task	Responsible	Year 1												Year 2											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Overall objective: to design environmental flows that would maintain and enhance biodiversity values and the functioning of the estuarine and deltaic ecosystems of the Lower Incomati in order to optimise the delivery of a number of key ecosystem services to a range of stakeholders and with the well-being of vulnerable user groups a priority.																									
Outcome 1	Constitution of a multi-disciplinary, multi-institutional and participatory research team for observation, monitoring, analysis and eflow scenario-development																								
Output 1.1 Observation and Monitoring of the wetland	O.H.																								
Output 1.2 Participatory workshops	All	W					W						W						W						W
Outcome 2	Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years																								
Output 2.1 Mapping of the key habitats	UEM																								
Output 2.2 Diachronic analysis of the past 70 years	IHE																								
Outcome 3	Analysis of the current freshwater flow pattern (as a driving indicator): we aim at analysing the quantity, quality and the spatial extent of the freshwater entering the key habitats of the Macaneta wetlands in the Lower Incomati (and their interaction with the tidal rythms)																								
Output 3.1, Activity 3.1.1. Hydrological analysis of discharge time series	UEM																								
O 3.1. Activity 3.1.2 Monitoring of water level and salinity	UEM + ARASUL																								
O 3.2 Activity 3.2.2	IHE																								

Production of flood inundation maps for different return periods																									
0 3.2 Activity 3.2.3 Dynamic spatial hydraulic modelling	UEM																								
Outcome 4	Identification and quantification of the relationships between the freshwater flow pattern and the coastal wetland productivity using biological proxies (plants, fish, birds)																								
Activity 4.1.1 Selection of the ecological proxies	UEM (Biology) and O.H.																								
Activity 4.1.2 and 4.1.3 Fish, bird and hydrology	UEM (Biology) and OH.																								
Activity 4.1.4 Mangroves																									
O 4.2. Activity 4.2.1 Participatory monitoring	Local Users under UEM Guidance																								
Objective 5	Ecosystem services analysis including a semi-quantitative analysis of links between the natural resource produced by the delta and the user livelihoods, at the household level and Comprehensive analysis of the stakeholders' natural resource use strategies																								
Activity 5.1.1 Ecosystem services survey	IRD																								
Activity 5.1.2 Typology of the main wetland user livelihood profiles	IRD																								
Activity 5.1.3 Household survey (initial survey + Monitoring over 12 months)	IRD																								

Activity 5.2.1 Stakeholders mapping	IRD																								
Activity 5.2.2 Analysis of the wetland users requirements	IRD																								
A.5.2.3 Map of the tensions and synergies between water needs (past and present																									
Objective 6	Jointly Develop and discuss Eflow scenarios that could optimize the wetland productivity, meet the downstream user needs and strategies and alleviate poverty																								
Activity 6.1 Spatial synthesis of the data	IHE																								
Activity 6.1 Scenario development (and workshops with decision makers)	IHE and all						W						W											W	

Annex 2: Logical Framework

Project title: Environmental Flows for enhanced Biodiversity and Poverty alleviation in the Incomati delta, Mozambique **EFLOWS-MOZ**			
Project overall objective: design environmental flows in order to optimise the ecosystem services of the Incomati delta and foster a multi-institutional and multidisciplinary team			
Project Results	**Outputs**	**Activities**	**Costs /output (US$)**
Outcome 1 Constitution of a multi-disciplinary, multi-institutional and participatory research team	O.1.1 Observation and participatory monitoring of the wetland	A.1.1.1 Detailed jointly designed logical framework for monitoring and regular monitoring of water, fish, birds, rainfall A 1.1.2 Participatory workshops (every 6 months)	**Sub – total: 43760**
Outcome 2.0 Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years	O.2.1 Map of the key habitats and Diachronic analysis of the past 70 years	A 2.1.1 Satellite image analysis A 2.1.2 Ground truthing	**Sub – total: 16800**
Outcome 3.0 Analysis of the current freshwater flow pattern and interaction with the tide	O.3.1 Analysis of quantity and quality of the freshwater entering the key habitats of the Macaneta wetlands	A 3.1.1 Hydrological analysis of discharge time series A.3.1.2 Monitoring of water level and salinity	
	O.3.2 Dynamic map spatial extent	A 3.2.1 Definition of topographic and bathymetric profiles A 3.2.2 Dynamic spatial hydraulic modelling	**Sub – total: 37000**

Outcome 4.0 **Hydro-ecology**	O.4.1 Identification and quantification of the relationships between the freshwater flow pattern and the coastal wetland productivity using biological proxies	A 4.1.1 Interaction between Fish and hydrological pattern A.4.1.2 Interaction between Birds and hydrological pattern A.4.1.3 Studying the nursery functions of the mangrove and wetlands	**Sub – total:63550**
Outcome 5.0 Ecosystem services, Livelihoods and Natural resource management strategies	O.5.1 Ecosystem services analysis and quantification	A 5.1.1 Ecosystem services survey A.5.1.2 Household survey (initial survey + Monitoring over 12 months)	**Sub – total:** **15000**
	O.5.2 Comprehensive analysis of the stakeholders' natural resource use strategies	A 5.2.1 Stakeholders mapping and their water requirements A.5.2.3 Map of the tensions and synergies between water needs (past and present	
Outcome 6.0 Jointly Develop and discuss Eflow scenarios that could optimize the wetland productivity, meet the downstream user needs and strategies and alleviate poverty years	O 6.1 Scenario development	A 6.1.1 Synthesis at the River basin level A 6.1.2 Scenario development (dam oeration and climate change)	**Sub – total:** **8750**
	O.6.2 workshops with decision makers(National and regional	A 6.2.2 Workshop (Month 24)	

Annex 3: Project Monitoring Plan

Project Title: Environmental Flows for enhanced Biodiversity and Poverty alleviation in the Incomati delta, Mozambique (EFlows-Moz)			
Project overall objective: The purpose (overall objective) of the project is to design environmental flows that would maintain and enhance biodiversity values and the functioning of the estuarine and deltaic ecosystems of the Lower Incomati in order to optimise the delivery of a number of key ecosystem services to a range of stakeholders and with the well-being of vulnerable user groups a priority. The project is seen as an implementation and testing of the EFA guidelines, and their adaptation to the Mozambican context. Hence, the experiences and results will allow Mozambique to contribute with ideas and proposals for further development of typical methodologies for eflows implementation by the WIO countries. It will also contribute to fostering of multidisciplinary team working to interface natural and social sciences.			
Project Results	**Indicator**	**Target/baseline**	**Method**
Outcome 1.0 Constitution of a multi-disciplinary, multi-institutional and participatory research team	IND.1.1 • Logical framework for mapping and regular monitoring of water, fish, birds, rainfall • Methodology manual	*Target*: generate a multidisciplinary and participatory research team that will start the monitoring of the wetland *Baseline*: there is no monitoring process of this wetland	• Meetings between the multidisciplinary actors, with clear task settings, and dissemination of meeting's notes • Field visits for multidisciplinary reconnaissance • Participatory workshops (every 6 months) • Definition of the methodology to be used for the subsequent Outcome 2.0
Outcome 2.0 Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years	IND.2.1. • Map of key habitats • Map of biodiversity values • Map of the changes in the Lower Incomati habitats, in the past 70 years • Training manual for mapping • Dissemination material	*Target*: create a new baseline for habitats and a change detection over the past 70 years *Baseline*: there is no updated mapping of habitats in the Lower Incomati	• Field visits for multidisciplinary reconnaissance, • Baseline map creation, by means of satellite image analyses and ground truthing • Change detection analyses of historical documents and datasets • Dissemination in plain language and in scientific language

Outcome 3.0 Analysis of the current freshwater flow pattern and interaction with the tide	IND.3.1. • Time series of freshwater and seawater fluxes • Time series of water salinity • Topographic profiles and bathymetric cross sections of the wetland • Hydrodynamic model, including water quality modelling	*Target*: understand the interactions between freshwater and sea water and their timing; build a dynamic spatial hydraulic model that incorporates quantity and quality of waters and their temporal variation *Baseline*: there is no monitoring of the freshwater/saltwater interaction in the study area. No groundwater monitoring exists and no sea water monitoring is in place so far	• Hydrological analysis of discharge time series • Monitoring of water level and salinity • Definition of topographic and bathymetric profiles • Dynamic spatial hydraulic modelling
Outcome 4.0 Hydro-ecology	IND.4.1. • Study on interactions between fish and hydrology • Study on interactions between birds and hydrology • Study on the nursery functions of the mangrove and wetland area	*Target*: generate the first comprehensive and multidisciplinary ecosystem service assessment of the wetland *Baseline*: there is a lack of understanding of the hydro-ecology of this wetland in general, and specifically of the interactions between hydrology, fish and birds populations	• Interaction between Fish and hydrological pattern • Interaction between Birds and hydrological pattern • Studying the nursery functions of the mangrove and wetlands

Outcome 5.0 Ecosystem services, Livelihoods and Natural resource management strategies	IND.5.1. • Study on ecosystem service assessment • Household survey (two)	*Target*: produce an Ecosystem services analysis and quantification, and generate the first Comprehensive analysis of the stakeholders' natural resource use strategies *Baseline*: there is a lack of ecosystem service assessment, livelihood assessment, and tensions & synergies in the study area	• Ecosystem services survey • Household survey (initial survey + Monitoring over 12 months) • Stakeholders mapping and their water requirements • Map of the tensions and synergies between water needs (past and present)
Outcome 6.0 Jointly Develop and discuss Eflow scenarios that could optimize the wetland productivity, meet the downstream user needs and strategies and alleviate poverty years	IND.6.1. • Document including a synthesis of the other Outcomes (1 to 5) • Document that defines different Eflow scenarios based on present and future dam operation rules and future changes in climate • Summary of the findings developed during the workshop to be held at month 24 of the project	*Target*: produce a document that will include Eflow scenarios, and organize and participate to a workshops with decision makers (National and regional) to consolidate the proposed Eflows *Baseline*: very little coordination between stakeholders exists at the moment. There is no Eflow scenario developed for the study area	• Synthesis at the River basin level • Scenario development (dam operation and climate change) • Workshop (Month 24)

Annex 4: Detailed budget

Activity	Category	Year 1					Year 2					Total Cost for 2yrs	
		Quantity*	Unit Cost (US$)	Total Cost (US$)	WIOSAP Support	Co-financing	Quantity	Unit Cost (US$)	Total Cost (US$)	WIOSAP Support	Co-financing	WIOSAP Support	Co-financing
Output 1.0 : observation and participatory monitoring of the wetland (Responsible : O. Hamerlynck)													
Activity A.1.1.1 Detailed jointly designed logical framework for monitoring and regular monitoring of water, fish, birds, rainfall	**Personnel (OH)**	6	830	4980	4980		5	830	4150	4150		9130	
	Personnel (Res. Assistant)	10	365	3650	3650		10	365	3650		3650	3650	4650
	Equipment (water gauges)	10	100	1000	1000							1000	5550
	Operating costs	1	500	500	500		1	500	500	500		1000	
	Contract Serv. (Gauge instal., observers)	8	730	5840	5840		8	730	5840	5840		11680	
	Travel	5	100	500	500		5	100	500	500		1000	2081
	Sub-total			***16470***	***16470***	***0***						***27460***	***12281***
A.1.1.2 Participatory workshops (every 6 months)	**Personnel (OH)**	15	830	12450	4150	8300	15	830	12450	4150	8300	8300	16600
	Equipment											0	
	Operating costs			500	500				500	500		1000	1000
	Contract Serv. (workshops)	3	1000	3000	3000		2	1000	2000	2000		5000	
	Travel	10	100	1000	1000			1000	1000	1000		2000	
	Sub-total			***16950***	***8650***	***8300***			***15950***	***7650***	***8300***	***16300***	***17600***
Total for Output 1.0				***33420***	***25120***	***8300***			***15950***	***7650***	***8300***	***43760***	***29881***
Output 2.0: Development of a comprehensive mapping of the key habitats and biodiversity values of the Lower Incomati and their evolution in the past 70 years (Responsible Paolo Paron)													
A 2.1.1 Satellite image analysis	**Personnel (PP)**	9	1000	9000	9000							9000	15666
	Equipment			1500	1500							1500	
	Operating costs												1000
	Contract Services												
	Travel												
	Sub-total			***10500***	***10500***				***0***	***0***		***10500***	***16665,65***
A 2.1.2 Ground truthing	**Personnel (PP)**	5	1000	5000	5000							5000	
	Equipment			300	300							300	
	Operating costs			500	500							500	500
	Contract Services											0	
	Travel	5	100	500	500							500	1748
	Sub-total			***6300***	***6300***	***0***	***0***	***0***	***0***	***0***	***0***	***6300***	***2248***
Total for Output 2.0				***16800***	***16800***	***0***	***0***	***0***	***0***	***0***	***0***	***16800***	***18914***
Output 3.0: Analysis of the current freshwater flow pattern and interaction with the tide (Responsible Dinis Juizo)													
A 3.1.1 Hydrological analysis of discharge time series	**Personnel (DJ)**	10	370	3700	3700	**5995**	10	370	3700	3700	**5995**	7400	11990
	Junior 1 (tbc)	10	200	2000	2000		10	200	2000	2000		4000	0
	Equipment												
	Operating costs			250	250	**250**			250	250	250	500	500
	Contract Services											0	0
	Travel											0	0
	Sub-total			***5950***	***5950***	***6245***	***20***	***570***	***5950***	***5950***	***6245***	***11900***	***12490***
A 3.1.2 Monitoring of water level and salinity	**Personnel (DJ)**	5	370	1850	1850		5	370	1850	1850		3700	
	Junior 1 (tbc)	5	200	1000	1000		5	200	1000	1000		2000	
	Equipment			7000	7000							7000	
	Operating costs			500	500	**500**						500	500
	Contract Services (dataloggers)			1000	1000				500	500		1500	
	Travel	5	100	500	500	**1041**	5	100	500	500	**1041**	1000	2081
	Sub-total			***11850***	***11850***	***1541***	***15***	***670***	***3850***	***3850***	***1041***	***15700***	***2581***
A 3.2.1 Definition of topographic and bathymetric profiles image analysis	**Personnel PP**	5	1000	5000		5000							5000
	Equipment			1000	1000							1000	
	Operating costs			500	500	**500**						500	500
	Contract Services (drone mapping)			1000	1000							1000	
	Travel	5	100	500	500							500	
	Sub-total			***8000***	***3000***	***5500***	***0***	***0***	***0***	***0***	***0***	***3000***	***5500***
A 3.2.2 Dynamic spatial hydraulic modelling	**Personnel (DJ)**	5	370	1850	1850		5	370	1850	1850		3700	
	Junior 1	5	200	1000	1000							1000	
	Equipment			600	600				600	600		1200	
	Operating costs			250	250	**500**			250	250		500	500
	Contract Services												
	Travel												
	Sub-total			***3700***	***3700***	***500***	***5***	***370***	***2700***	***2700***	***0***	***6400***	***500***
Total for Output 3.0				***23550***	***18550***	***7541***			***6550***	***6550***	***1041***	***37000***	***21071***

Output 4.0: **Identification and quantification of the relationships between the freshwater flow pattern and the coastal wetland productivity using biological proxies**													
A 4.1.1 Interaction between Fish and hydrological pattern	**Personnel OH**	5	700	3500	3500		5	700	3500	3500		7000	
	personnel AM	20	350	7000	7000	**1000**	15	350	5250	5250	**1000**	12250	2000
	Junior 2	20	200	4000	4000		15	350	5250	5250		9250	
	Equipment			500	500				500	500		1000	
	Operating costs			500	500	**500**			500	500	500	1000	1000
	Contract Services												
	Travel	20	100	2000	2000		20	100	2000	2000		4000	
	Sub-total			***14000***	***14000***	***1500***			***13500***	***13500***	***1500***	***34500***	***3000***
A.4.1.2 Interaction between Birds and hydrological pattern	**Local consult.**	20	250	5000	5000		15	250	3750	**3750**		8750	
	Equipment			300	300					-		300	
	Operating costs									-			
	Contract Services (Ringing)			5000	5000				5000	5000		5000	
	Travel	10	100	1000	1000		10	100	1000	1000		2000	
	Sub-total			***11300***	***11300***	***0***	***25***	***350***	***9750***	***9750***	***0***	***16050***	***0***
A.4.1.3 Studying the nursery functions of the mangrove and wetlands	**Mangrove ecologist**	10	350	3500	3500		10	350	3500	3500		7000	
	Junior 3 (tbc)	10	200	2000	2000		5	200	1000	1000		3000	
	Equipment												
	Operating costs												
	Contract Services												
	Travel	15	100	1500	1500				15	100	**1500**	3000	1500
	Sub-total			***7000***	***7000***	***0***	***15***	***550***	***4515***	***4600***	***1500***	***13000***	***1500***
Total for Output 4.0				***32300***	***32300***	***1500***	***40***	***900***	***27765***	***27850***	***3000***	***63550***	***4500***
Output 5.0: Ecosystem services, Livelihoods and Natural resource management strategies (Responsible Stéphanie Duvail)													
A 5.1.1 Ecosystem services survey	**Personnel SD**	10	600	6000		**6000**						0	6000
	Equipment		1000	1000	1000							1000	
	Operating costs			500	500	**500**						500	500
	Contract Serv.												
	Travel	5	100	500	500							500	
	Sub-total			***8000***	***2000***	***6500***	***0***	***0***	***0***	***0***	***0***	***2000***	***6500***
A 5.1.2 Household survey (initial survey + Monitoring over 12	**Personnel SD**	10	600	6000		**6000**						0	6000
	Equipment											0	
	Operating costs												
	Contract Serv.												
	Travel	5	100	500	500	**2063**						500	2063
				6500	***500***	***8063***	***0***	***0***	***0***	***0***	***0***	***500***	***8063***
A 5.2.1 Stakeholders mapping and their water requirements	**Personnel SD**	10	600	6000		**6000**	10	600	6000		**6000**		12000
	Personnel RD	10	750	7500	7500		11	750	8250		**8250**	7500	8250
	Equipment												
	Operating costs												
	Contract Serv.												
	Travel	10	100	2500	2500		10	100	2500	2500		5000	2498
A 5.2.2 Map of the tensions and synergies between water needs (past and present	***Sub-total***			***16000***	***10000***	***6000***	***31***	***1450***	***16750***	***2500***	***14250***	***12500***	***22748***
	Personnel RD						11	600	6600		**6600**		6600
	Equipment												
	Operating costs												
	Contract Serv.												
	Travel												
	Sub-total			***0***	***0***	***0***	***11***	***600***	***6600***	***0***	***6600***	***0***	***6600***
Total for Output 5.0				***30500***	***12500***	***20563***	***42***	***2050***	***23350***	***2500***	***20850***	***15000***	***43910***
Output 6.0: **Jointly Develop and discuss Eflow scenarios that could optimize the wetland productivity, meet the downstream (Elidio Massuanghane et Dinis Juizo)**													
A 6.1.1 Synthesis at the River basin level	**Personnel EM**	5	350	1750	1750	**1000**	10	350	3500	3500	**1000**	5250	2000
	Equipment												
	Operating costs								250	250	500	250	500
	Contract Serv.												
	Travel										2081		2081
	Sub-total								***3750***	***3750***	***3581***	***5500***	***4581***
A 6.1.2 Scenario development (dam oeration and climate change)	**Personnel EM**						5	350	1750	1750	**4995**	1750	4995
	Equipment												
	Operating costs												
	Contract Serv.												
	Travel						1	1500	1500	1500		1500	
	Sub-total								***3250***	***3250***	***4995***	***3250***	***4995***
Total for Output 6.0									***7000***	***7000***	***8576***	***8750***	***9576***
Grand total				136570	105270	37903			80615	51550	41767	**184860**	**127853**
											Management 8%	*14788,8*	
												199649	

Annex 4.1: Budget Summary (Total budget for the Output applied for MUST NEVER exceed the ceiling given in the background document)

	Category	Quantity	Unit Cost (US$)	Total Cost (US$)	WIOSAP Support	Co-financing	
1.	Personnel			220381	118630	101751	
2.	Equipment			19850	14300	5550	
3.	Operating costs			12750	6250	6500	
4.	Contract Services			24180	24180	0	
5.	Travel			35552	21500	14052	
					184860	127853	312713

Definitions

- **Personnel:** This will be critical personnel required for the successful implementation of the project e.g. a Project Coordinator. Such a role can also be cost-shared with another ongoing project, which has complementary interventions to the proposed WIOSAP project. This category will also include required consultants who may be required for critical technical expertise in the project.
- **Equipment:** This will include a computer, printer, any required office furniture, critical water quality measuring instruments of a reasonable and cost-effective budget etc.
- **Operating costs:** Will include internet, mailing and where very necessary, telephone charges. Will include stationary, fuel and other necessary inputs without a recurring value.
- **Contract services**: Where external services will be required to bring in critical expertise e.g. contractors for construction works etc. This category also includes meetings/workshops e.g. contracted conference package.
- **Travel:** To include ticket costs, local transport and daily subsistence allowance.

Annex 4.2: Budget justification

	Category	**Justification**
1.	**Personnel**	To cover cost of personnel during the implementation of the project. The cost have been calculated based on standard staff cost applied by the institutions for similar project. Significant co-funding is included in this component. The cost of French staff is covered by the IRD.
2.	**Equipment**	Some equipment is already available with the team but additional equipment is necessary to monitor water quality on site. GIS component will also required the acquisition of robust computing IT equipment. There will also be a need to setup longterm field monitoring tools.
3.	**Operating costs**	Include cost for field work, servicing of vehicles, communication and other running cost. Part of the costs are covered as co-funding by the institutions involved.
4.	**Contract Services**	There certain specialists' studies of short duration that might require the hiring of additional experts such as installation of river gauge, bird ringing, etc.
5.	**Travel**	Project members and engaged experts/ consultant will need transport for fieldwork and for attending meeting/workshop events. Transport costs and daily subsistence allowance will be paid from this budget. Cofunding is provided.