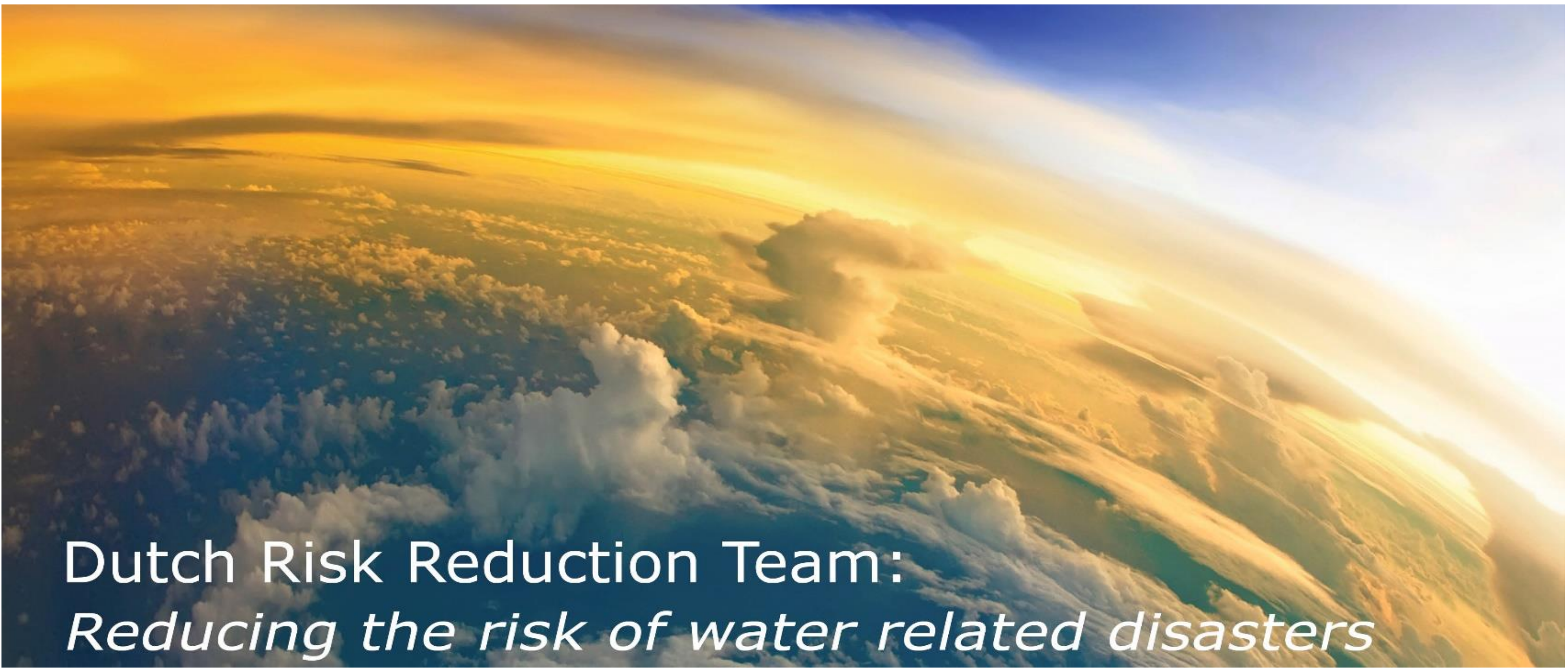
Kingdom of the Netherlands



DRR-Team Mission Report

Mozambique – Licungo Basin

15 June 2015

15 June 2015
DRR-Team Scoping Mission, Final Report
Flood Control in the Licungo Basin of Zambezi Province

DRR-TEAM MOZAMBIQUE

Document title	DRR-Team Scoping Mission Report
Status	Final Report
Date	15 June 2015
Project name	DRR-Team Scoping Mission in Mozambique
Reference	DRR14MZ01

SUMMARY

INTRODUCTION

From 11 – 21 April a scoping mission was carried out to the Licungo basin in Mozambique. The objectives were to analyse the flood events of January 2015 in the Licungo Basin, assist the Mozambican government in the assessment of the dikes protecting Nante in the Licungu Basin and the dikes near Marromeu in the Zambezi Valley, advise the Government of Mozambique on prioritising flood recovery actions and elaborate on a roadmap for medium- and long-term interventions to reduce the risks and impacts of future floods. The DRR-Team spent a few days in Maputo to convene with the national authorities, the Netherlands Embassy and the World Bank. Subsequently a field visit was made to the Licungo Basin to meet with the local representatives of the different water-relevant ministries and district authorities. The Zambezi Development Authority (ZVDA) made a helicopter available which enabled the DRR-Team to complete the dike inspection.

ANALYSIS OF HYDROLOGICAL EVENTS

The analysis of the flood in the Licungo Basin indicates extreme amounts of precipitation in the entire catchment related to a (binary) cyclone event on the Indian Ocean. The analysis gives an estimated peak discharge of about 19,000 m3/sec. however; more study is required as a runoff coefficient has not yet been established. Drainage to the sea in the lower Licungo seems blocked in the coastal zone and needs further analysis.

According to protocol, DNA bulletins are set up once a day and state the situation as recorded at 6am. Extreme events later during the day remain unregistered until the next day. Local authorities (ARA) transmit more up-to-date warnings. The extreme rapidity of the 2015 flood limited the warning time, which was aggravated by a lack hydrometric automatic stations (rainfall and hydrometrical) and rainfall forecasts.

Casualties during the 2015 Licungo flood were dominant in the upper reaches of the basin and were unrelated to dike failures. Most probably they were caused by the occurrence of heavy flash floods, but this needs to be investigated further.

Mocuba experienced an exceptional water level increase causing heavy damage to roads and destruction of the bridge, which acted as significant obstruction to flow during the 2015 flood. Most probably the bridge openings are too small in relation to the peak discharges to be expected. Also the Mopeia bridge was destroyed.

FIELD VISIT TO THE LICUNGO BASIN AND MARROMEU

With a figure of USD 155 million (WB/UN/EU report), most of the flood damages have been attributed to roads and bridges. In the WB-report damages to dikes were estimated at USD 6.7 million. The DRR-Team estimates a total cost of USD 7.7 million, excluding the mobilisation of equipment. In the agricultural sector, damages were assessed at USD 81 million on crops and USD 14.2 million on irrigation infrastructure, reflecting the necessity of vulnerability reduction from floods (WB/UN/EU-report).

This budget enables rehabilitation to the situation before the floods but it is doubtful whether it is sufficient to finance the costs associated with reducing the flood vulnerability of roads, bridges, dikes, embankments and irrigation areas to a sustainable level. This requires substantial redesign, i.e. gentler dike gradients to allow overtopping without major damage and replacement of bridges which are under-designed and not able to pass the floods.

An important agricultural-irrigation project in the lower Licungu Basin is the Munda-Munda project. During the 2015 flood, the hydraulic infrastructure of the Munda Munda irrigation area was much destroyed. Considering the much higher than expected flood levels, a rethink is required on the design of the new gravity feed irrigation infrastructure, and the optimum, economically feasible dike dimensions. This consideration will delay the implementation of the river works of the project.

RESULTS AND FINDINGS

The Licungo Basin is a relatively unspoilt, natural river basin. There is a limited number of dikes in the lower flood plains so the river flows more or less unobstructed through the basin in a natural system. At the same time, the fertile flood plains offer substantial potential for the development of irrigated agriculture. Dikes which are constructed close to the river to keep the water out of the agricultural areas will however impact on the capacity of the river to discharge its water. In times of floods the loss of retention capacity will lead to strongly rising water levels and eventual loss of lives, destruction of infrastructure and major loss of income. Even with the limited number of dikes present now, the floods are capable of severe destruction, as witnessed in most recently in 2013 and 2015.

Although the responsibility for maintenance of dikes in relation to their respective use functions (such as roadway, embankment and flood protection) is defined in theory, maintenance of dikes is generally lacking. This issue is particularly relevant for the population living around the SENA Sugar Estate in Marromeu where dikes are in a state of considerable disrepair.

There is an increase in political ownership in water resources in DNA/ARAs as evident from the resent initiative of DNA in developing a National Flood Management Strategy, but there is still a lot to gain in the prevention and mitigation of floods and adaptation measures in flood plains. Floods have devastating impact on all sectors of society. Socio-economic development is disrupted because of wide-spread destruction, not only of dikes and embankments, but also of roads, bridges, power lines, housing, agricultural fields and infrastructure. There is a strong socio-economic development reason and business case for integrated solutions which demand effective cooperation between different sectors in order to reduce the risk of floods.

A positive development is the active participation, besides DNA and the ARAs, of INGC, MITADER, ZVDA and especially INIR both at national and at provincial level, to represent the interests of agriculture and irrigation in the socio-economic development of the Licungo Basin. The floods are also highly significant for ANE as the vast majority of the damage was related to access roads to bridges and the bridges themselves and it is advised that efforts be undertaken to review the flood risks to the road and bridges infrastructure in the country.

RECOMMENDATIONS AND PROPOSED FOLLOW-UP ACTIVITIES

Strengthening Water Governance for Integrated Solutions

Often, a water management crisis is also a (water) **governance** crisis. Not only technical expertise ("hardware", structural measures) is needed to solve water-related problems, but also knowledge of the organisation of water management and the way it is embedded in political, legal, social and financial arrangements ("software", non-structural measures). The techniques for water management and flood control are generally available but bottlenecks often are related to governance challenges such as institutional fragmentation, lack of systematic planning and solid financial systems. It is strongly recommended to strengthen "Good Water Governance" practices in Mozambique as an important overarching theme for increasing water security, water safety and sustainable economic development. Governance focuses on the institutional, legal, administrative, financial and economic capacities of all stakeholders including the governmental ones, and on communication between and participation of all stakeholders, taking into consideration the social necessities of the society (be it on national, regional or local level).

As regards water governance it is recommended that DNA and the ARAs take the lead in this process. Floods are a continuous risk factor for the Mozambican economy and society and it is recommended that DNA and the ARAs actively facilitate such process, assisting the other sector ministries in managing these flood-related risks.

The specific recommendations following from the DRR-Team are both structural and non-structural:

Structural measures

I First priority is to repair the dikes near Nante. Considering the fact that the next flood season is only 6 months away, a phased approach is recommended. In phase 1, there is only time to repair the dikes with the same cross-section and to the same level as before the floods. It is recommended that DNA defines the TOR and arrange financing for the contracting of dike repair works at Nante as soon as possible and to start repair work preferably in August, at the latest on September 1, 2015;

II In phase 2, the embankment system of the dikes around Nante should be redesigned to become more resilient. This will probably involve substantial earth works, and possibly relocation of embankments to allow for sustainable agricultural development. Such resilient design includes the capability of dikes being overtopped during more extreme floods. Final recommendations depend on careful analysis and study so phase 2 is not foreseen until the spring of 2017;

III It is recommended to give high priority to the further rehabilitation of Mocuba Bridge (abutments, revetments), which has been temporarily repaired in order provide more protection during the next flood season. In the medium term, more detailed analysis is necessary to establish the required bridge span and openings to withstand peak floods as the bridge is probably under-designed, this should be done in close cooperation with ANE.

Non-Structural Measures

IV DNA is currently procuring the Licungo Basin Water Resources Development Plan (LBWRDP). This water management plan will indicate the direction in which agriculture and (processing) industry will develop in the basin and indicate the most promising investment locations. The discussion on flood protection levels for the areas to be developed, keeping in mind future adaptations in the agricultural sector is not sufficiently addressed in this plan so a specific flood management study is necessary. The DRR-Team recommends linking the outcome of the LBWRDP closely with further necessary studies on flood management and agricultural development;

V It is recommended that DNA carries out a study to determine the return period of the 2015 Licungo flood and earlier floods as to provide basic information for the redesign or reconstruction of bridges and provide input to the design of the embankment system to be developed for agricultural expansion;

VI The DRR-Team advises INGC to further investigate the cause of the flood fatalities as most of them occurred in the upstream areas and which were not due to dike failures, in order to improve early warning procedures;

VII It is recommended that DNA develops, prior to the Licungo Basin Flood Management Plan (LBFMP), a pilot hydrological and hydrodynamic model of the Licungo Basin to provide more insight in return periods, the (re)establishment of hydromet stations, the relation between embankment heights, retention capacity and sustainable agricultural production;

VIII The DRR-Team recommends the elaboration of the Licungo Basin Flood Management Plan (LBFMP), which complements the Licungo Water Resources Development Plan (LBWRDP) already under procurement of DNA. It is advised that the TOR for the LBFMP is drafted as soon as possible, during the inception phase of the LWRDP;

IX In order to implement the Munda Munda Irrigation project in a sustainable way it is necessary to determine the resilient design of the embankment system and regulating structures. Close collaboration with INIR and the provincial departments is required to arrive at agreed feasible return periods and related dike height in combination with more resistant dike slope sections to withstand overtopping during bigger floods. In order to limit the delay in the implementation of the Munda Munda project it is recommended that the pilot model (see VII) is extended in more detail to facilitate final design of the project, aided by additional information coming available from the LBFMP;

X Using the results of the pilot flood model, the DRR-Team recommends to make a preliminary hydrological analysis to determine the optimal conveyance capacity of Mocuba bridge (most probably under-designed at this moment) to reduce the flood vulnerability and prevent destruction in the future. The results can be used to prepare the TOR for final design of a new bridge in the future. Attention should also be given to the water intake of AIAS which was destroyed during this flood;

XI It is recommended to re-establish some of the old hydrometric stations in the tributaries but also in the main stream of Licungo River, most of which have been abandoned, based on the outcome of the pilot model;

XII It is recommended to analyse and improve the hydro-climatic monitoring network in the Licungo Basin, in particular the need for some automatic stations;

XIII The DRR-Team recommends that DNA is strengthened in the use of real-time satellite information in flood early warning modelling and prediction to shorten warning lead times;

XIV The DRR-team recommends executing a nation-wide preliminary mapping of flood hazard areas;

XV It is recommended to execute a preliminary nation-wide survey of flood vulnerability of major infrastructure, such as dikes and embankments, irrigation infrastructure, road and railway bridges and power lines as part of a National Flood Plan. Eventually, basin flood management plans will need to be made which define, among others, the hydraulic boundary conditions for rehabilitation of existing structures and design of new ones;

XVI Presently institutions, donors or governmental agencies are introducing different flood models and decision support systems as part of their assistance to DNA in relation to flood management. The operation and maintenance of different systems is costly and there is insufficient capacity to maintain knowledge on all systems in the different regions and ARAs. It is recommended that DNA carry out analysis of the flood models and decision models and coordinate and rationalise the model suite used in the water resources management and flood management;

XVII It is recommended that DNA and the ARAs take in hand the strengthening of the planning processes between the water-relevant sectors, such as agriculture, energy, transport corridors (roads and railways), urban and rural planning to achieve integrated solutions for flood risk reduction. This includes the promotion of good water governance among the socio-economic development sectors mentioned above.

TIMELINE PROPOSED MEASURES AND FOLLOW-UP

Tabe 2 Recommended Short and Medium Term Activities

		Activity	Who	Cost m$
		At the Level of the Licungo Basin		
I	1	Preparation TOR emergency repair dikes near Nante	DNA	
	2	Procurement and selection of contractor	DNA	
	3	Emergency repair of dikes near Nante	Emp	7.7
II	4	Resilient design and final rehabilitation of dikes near Nante	DNA/INIR	7.5
III	5	Further rehabilitation of Mocuba bridge before next flood season	ANE	n/a
IV	6	Procurement Strategic Water Resources Dev. Plan Licungo	DNA	
	7	Elaboration of the Strategic Water Resources Dev. Plan Licungo	Cons.	1.0
V	8	Study and analysis return period of floods Licungo	DNA	p.m.
VI	9	Analysis cause flood fatalities in the Licungo Basin	INGC	n/a
VII	10	Definition of a Pilot Hydrodynamic Model of the Licungo	DNA	
	11	Elaboration of Pilot Model	DNA	0.2
VIII	12	Preparation TOR Integrated Flood Management Plan Licungo	DNA	
	13	Procurement and selection consultant	DNA	
	14	Elaboration of the Integrated Flood Management Plan	Cons.	1.0
IX	15	Advise INIR on adaption river works and infrastr. Munda Munda	DNA/INIR	0.2
X	16	Preliminary hydrol. analysis conveyance capacity Mocuba bridge	DNA/ANE	0.1
XI	17	Re-establishment of old hydrometrical stations in the Licungo*	ARA-CN	1.0
XII	18	Analyse, improve and implement hydro-climatological network*	DNA/ARA	0.4
		At the National Level		
XIII	19	Capacity building use of satellite information for early warning	DNA	p.m.
XIV	20	Nation-wide mapping of the flood hazard areas	DNA	p.m.
XV	21	Preliminary analysis of flood vulnerability of major infrastructure	DNA	p.m.
XVI	22	Rationalise the model suite on water and flood management	DNA	p.m.
XVII	23	Strengthen inter-sectorial planning for integrated solutions	DNA	p.m.
		* = rough estimate only, needs to be confirmed		19.1

The indication "n/a" in the column "cost" signifies that these costs do not fall under the responsibility of DNA.

FINANCIAL AND ECONOMIC ASSESSMENT AND OPPORTUNITIES

In the Licungo Basin there is considerable potential for agricultural and irrigation development, particularly for rice and tea. Forestry and pulp industries are also being planned for this river basin. The Licungo floodplain downstream of Mocuba is primarily used for subsistence agricultural production but there is also a good market for an increased production of rice, as Mozambique is importing rice to supplement it needs.

Table 2 presents an overview and planning of the activities recommended by the DRR-Team which includes investment needs in the form of bankable projects, opportunities for consultants for execution of studies and commercial opportunities in agriculture.

Bankable Projects

The tendering of urgent actions under Activity I (rehabilitation of dikes at Nante) has already been undertaken by DNA and the LBWRDP financed by DNA is already in procurement (Activity IV)

From the **World Bank** side (reference is made to the AID Memoire Flood Rapid Assessment Licungo River, Mozambique, P155440, Adri Verwey, June 2015), various initiatives could be taken to investigate financing options for technical assistance and flood management works in Licungo Basin. The needs are:

- Flood Management Plan for Licungo Basin (LBFMP); Activity VIII
- Re-establishment of the hydro-meteorological network; Activity XI ad XII
- Resilient design and final rehabilitation of the existing dikes at Nante and Marromeu; Activity II
- Construction of upstream reservoirs, new dikes, diversion canals, improved roads, etc.; as follow-up results of from Activity VIII
- Resilient design and final rehabilitation of the bridges crossing Licungo River at Macungo and Malei. Follow-up of Activity X

The **Dutch Government** could take the initiative to support the development of the pilot hydrodynamic model of the Licungo as precursor to the LBFMP and advise DNA in the necessary fieldwork activities such as a river cross-section survey programme. This activity could be part of the 2-year Dutch-financed Strategic Technical Assistance programme starting in June 2015. This would provide the basic information to initiate Activities V, IX and X.

Activities XIII – XVII are national, strategic actions which will be worked out further in cooperation with the Dutch TA programme.

As regards governance, the Dutch government could take the initiative to increase support for the implementation of governance as an essential feature for effective water and flood management. This could be undertaken as component of the broader water programme in Mozambique (Ref: Multi-Annual Strategic Plan (MASP) for the period 2014-2017).

Consulting Opportunities

A number of consulting opportunities are presented: the Licungo Basin Flood Management Plan, the resilient design of the embankment system near Nante and the final design of the Mocuba and Malei bridges. In the course of the next few years other needs and priorities will be identified in securing major infrastructure in Mozambique from floods, including a number of feasibility studies.

Commercial Opportunities

Currently, a 3,000 ha irrigation scheme is under development at Munda Munda, with financial input for RVO-ORIO funds, just downstream of Nante. With an expected yield of 3 tons per ha, the rice to be produced in Munda Munda is a biologically friendly product.

For the right bank Lower Licungo project (Namacurra District), an investment opportunity is being prepared for the first DRIVE call later this year for the development of 5,000 ha of land for the irrigation of rice. INIR will be the owner and will negotiate an AdB loan, while the Dutch RVO.nl will facilitate the process with additional funds and services. For RVO support however, a Dutch company must be one of the participants. So it is necessary to raise the interest of Dutch companies to participate in organizing the rice value chain for the Mozambican market (import substitution) for 80% of the production and to open an export line to Europe with organic, aromatic and fair trade rice (a new product) for the remaining 20%. Related to this is the negotiation of a management contract with the Mozambican Government for the use of the (Chinese) rice mill at Namacurra.

ACKNOWLEDGEMENTS

The DRR-Team expresses its sincere gratitude to all officers and personnel of the national and regional authorities and provincial government for receiving the team, providing them with the necessary assistance and information and taking part in discussions on water management and flood control.

The DRR-Team would also like to thank the local resource persons Álvaro Vaz and Jan de Moor for their valuable contribution, and to Adri Verwey, of the WET team of the World Bank, who accompanied the DRR-Team for his valuable comments and his suggestions as to the identification of potential bankable projects in relation to the WB programme in Mozambique.

CONTENTS

LIST OF ABBREVIATIONS

AfDB	: African Development Bank
AIAS	: Water and Sanitation Infrastructure Administration
ARA	: Regional Water Administration
ARA CN	: Regional Water Authority Centre-North
DNA	: National Directorate of Water
DPASA	: Provincial Directorate of Agriculture
DPASA	: Provincial Directorate of Agriculture
DPASA/DAS	: Provincial Directorate of Agriculture/Department of Water and Sanitation
DPCCN	: Department of Prevention and Combat to Naturals Calamities
DPOPHZ	: Provincial Directorate of Public Works Zambezi
DRR	: Disaster Risk Reduction
DRRMC	: Disaster Risk Reduction Management Cycle
DSS	: Decision Support System
EIA	: Environmental Impact Assessment
GFDRR	: Global Facility for Disaster Reduction and Rehabilitation
INGC	: National Institute for the Management of Natural Disasters
INIR	: National Institute of Irrigation
IWRM	: Integrated Water Resources Management
LIDAR	: Light Detection And Ranging
MITADER	: Ministry of Land, Environment and Rural Development (former MICOA)
MOFA	: Ministry of Foreign Affairs
MOPHRH	: Ministry of Public Works, Housing and Water Resources
MSP	: Multi-Sectorial Planning
NCEA	: Netherlands Commission of Environmental Assessment
ORIO	: Development-Relevant Infrastructure Development (fund), Netherlands
PEOT	: Special Plan for the Spatial Planning
PNDRH	: Programa Nacional de desenvolvimento de Recursos Hídricos
SEA	: Strategic Environmental Asessment
TOR	: Terms of Reference
WB	: World Bank
WGC	: Water Governance Centre, The Hague
WPC	: Water Diplomacy Consortium, The Netherlands
ZVDA	: Zambezi Valley Development Authority

1 BACKGROUND

1.1 International Context

The climate change scenarios which the Intergovernmental Panel on Climate Change has pictured for the Southern African region are all indicating an evolution towards prolonged drought periods and more extreme floods. As Mozambique is a delta country, the risk of extreme flooding is largely dependent of what happens upstream. In the beginning of 2015 all countries upstream such as Malawi, Zimbabwe and Zambia received significantly heavy rains. The combination of upstream countries' water run-off and local rainfall has resulted in an unprecedented rise in the water levels of the Licungu and Zambezi Rivers in Mozambique.

1.2 Context of Mozambique and Zambezi Province

Mozambique National Context

The National Directorate for Water Affairs (DNA) has the leading role in making Mozambique safer. Both the short-term interventions and longer-term strategies must ensure that future floods will be less extreme, and that impacts are minimized through better protection, better mitigation and better adaptation.

Context Zambezi Province

Zambezia, see Figure 1, is the second most-populous province of Mozambique, located in the central coastal region south-west of Nampula Province and north-east of Sofala Province. It has a population of 3.85 million (census 2007). The provincial capital is Quelimane.

Zambezia has a total area of 103,478 km2, much of it drained by the Zambezi River and the Licungu River. The Licungu Valley has the highest potential for the development of rice production of Mozambique and it is very densely populated. More than half of the labor involved in rice production is carried out by women. Parts of Zambezia received abnormally high levels of rainfall -- 600 millimetres of rain in 10 days. It caused floods on 12 January and following days, which have cut the main north-south road in two and left Nampula, Niassa and Cabo Delgado provinces without electricity for more than a month.

Figure 1 - Map of Mozambique, Zambezia Province and Capital Quelimane

The 2015 flood of the Licungo River at Mocuba was possibly worse than the previously most-extreme flood event of 1971. In 2015 at least 150 people died according to the National Disasters Management Institute (INGC). The number of people affected by the floods is put at about 150,000. Meanwhile 3,500 hectares of crops were lost and another 30,000 ha were damaged. It also affected the activities in the framework of ORIO aimed at food security for 5,000 smallholders and import reduction of rice with a market volume of 6,000 tons a year.

Relation Netherlands – Mozambique

The Embassy of the Kingdom of the Netherlands (EKN) is implementing its Multi-Annual Strategic Plan (MASP) for the period 2014-2017. The MASP focuses on cooperation with Mozambique on Water- and Sanitation, Economic Development, Food Security and Agribusiness and Sexual and Reproductive Health Rights.

The Water programme has three pillars: integrated water management through support to the Mozambican Water boards, water & sanitation through support to Public Private Partnerships and institutional support to the National Directorate of Water.

Furthermore, to reinforce bilateral cooperation the "Water Mondiaal Programma" was started in 2009. This program encourages cooperation between governmental organizations, knowledge institutes, businesses in the private sector and non-governmental organizations. It also aims to strengthen cooperation with EU, UN and World Bank in the area of flood prevention as the DRR-Team mission is complementary to the WB-UN and EU activities (see below). Finally, the programme may be in aid of the implementation of the (partly) ORIO-financed Munda Munda irrigation project because these activities contribute to minimising risk in implementation of such projects.

2 DRR-TEAM MISSION

2.1 Introduction

An official request for support from the DRR-Team was sent to the Dutch Government through the National Government of Mozambique, Ministry of Public Works, Housing and Natural Resources, National Directorate of Water (DNA) on the 2nd of February 2015. A description of the Dutch Risk Reduction Team (DRR-Team) Facility is presented in Annex A. The composition of the DRR-Team for this mission is presented in Annex B. The TOR for this mission is presented in Annex C and the request for support is in Annex D.

2.2 Scope of Work

The DRR-Team was requested to evaluate, where possible, the state of the dikes protecting Nante in the Licungo Basin and Marromeu in the Zambezi Basin, to assist DNA in developing flood inundation maps and assist DNA in the development of a post-flood plan for priority and strategic actions to respond to the flood affected areas.

2.3 Approach

In preparation of the mission a review was made of the available documentation on the disaster situation by national and international organisations. The DRR-Team spent several days in Maputo to convene with the national authorities, such as DNA, MICOA, NIRI and INGC, the Netherlands Embassy and the World Bank. Subsequently a field visit was made to the Licungo Basin to speak with the local representatives of the different water-relevant ministries, the district authorities and the Regional Water Authority ARA Centro-Norte. Brief minutes of the meetings in Maputo and in the field are presented in Annex E.

Key part of the field visit was the inspection of dikes in the area of Nante and in Marromeu for which a cost estimate for emergency repairs has been requested. The DRR-Team ended with a debriefing in Quelimane, Licungo Basin, and in Maputo, at the Dutch Embassy and at DNA. The DRR-Team was accompanied by a representative of the water group of the World Bank to liaise with the financing programme of the World Bank in Mozambique and the Programme of the Dutch Embassy. The mission programme is presented in Annex F. This report summarizes activities and findings of the DRR-Team.

2.4 Objectives

The objectives of the scoping mission are:

- Analyse the hydrological events of January 2015 in the Licungo Basin, including an overview of the corresponding inundations (Chapter 3);
- Assist the Mozambican government in the assessment of the dikes protecting Nante and Marromeu in the Licungu Basin (Chapters 4 and 5);
- Assist and advice the Government of Mozambique on prioritising flood recovery actions (Chapter 6);
- Elaborate on a roadmap for medium- and long-term interventions to reduce the risks and impacts of future floods (Chapter 7).

3 ANALYSIS HYDROLOGICAL EVENTS JANUARY 2015

3.1 Introduction

The Licungo River Basin, with an area of about 30,000 km2, see Figure 2, resides within the country borders of Mozambique. Its floods are caused by high intensity rainfall in the high mountains upstream (Guruè and Milange areas) that feed the river and its main tributary, the Lugela River. After the confluence, near Mocuba, the river enters into a low lying area in the Maganja da Costa district. Due to the large extension of the flood plain, the water level does not rise much for the small and intermediate floods but, in the floods of 2001 and 2013, the water levels were much higher and caused significant damages.

In 2013 the Licungo Basin was also visited by a flood scoping mission. The 2013 flood was the largest after the 2001 flood, and 11 people died in Maganja da Costa. The inundation was extensive, cutting the roads and isolating communities and villages, due to the prolonged rainfall that created an enormous flood volume. Usually the floods only last a few days but the 2013 flood lasted unusually long. Large damage resulted: dikes were cut, irrigation infrastructure was damaged, roads were cut and communities isolated for days. For details about the 2013 floods, reference is made to the report "Scoping Mission on the technical Assistance for Improved Flood Mitigation through Integrated Land and Water Management in the Lower Zambezi Valley", 15 June 2013.

The flood of January 2015 was even more extreme than the 2013 flood. The flood of 2015 developed extremely fast and led to more than 100 casualties, to extensive infrastructural damages, numerous dike breaches and to widespread agricultural losses. See also the WB/UN/EU report "Mozambique 2015: damage assessment and early recovery / sustainable reconstruction priorities", 12 April 2015.

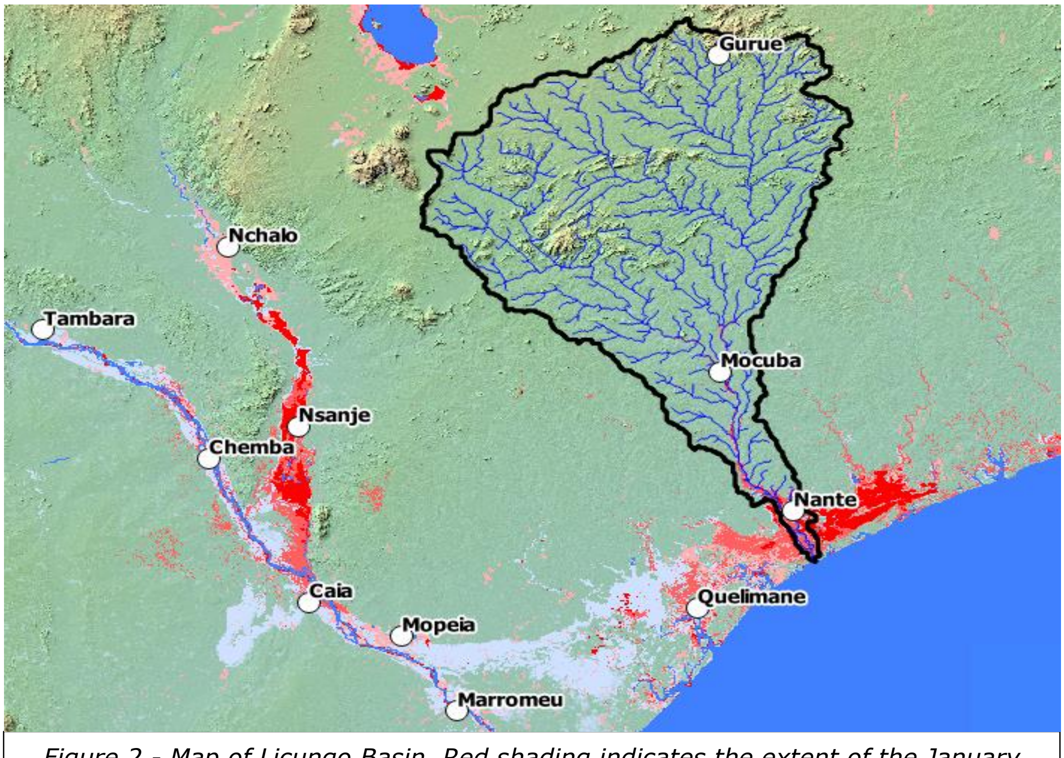


Figure 2 - Map of Licungo Basin. Red shading indicates the extent of the January 2015 flood along the Shire (Nichalo, Nsanje), the Zambezi (Tambara, Marromeu) and the Licungo Rivers (Gurue, Mocuba, Nante).

3.2 Rain and Runoff Volumes During the 2015 Licungo Flood

In January 2015 a binary cyclone system on the Indian Ocean (Figure 3) led to heavy rainfalls offshore and on the Mozambican and Madagascar mainland. Here we focus the attention to the peak rain quantities that fell in and surrounding the Licungo River Basin in Mozambique, which were responsible for the severe floods in the region.

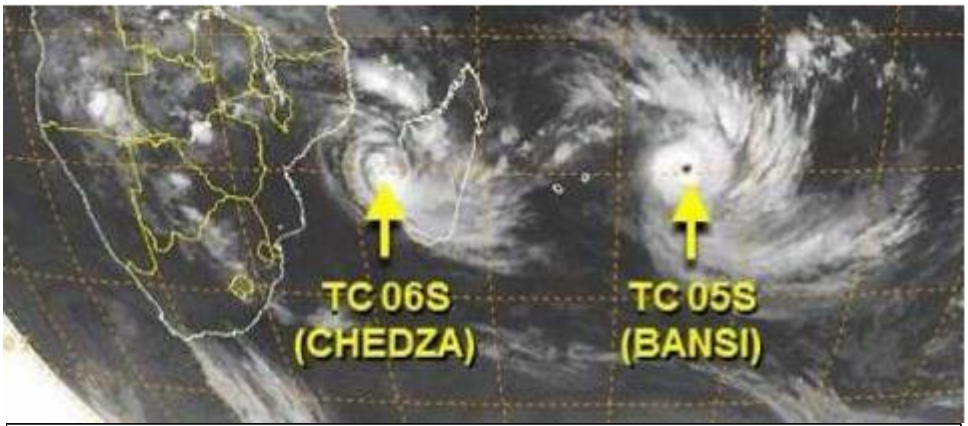
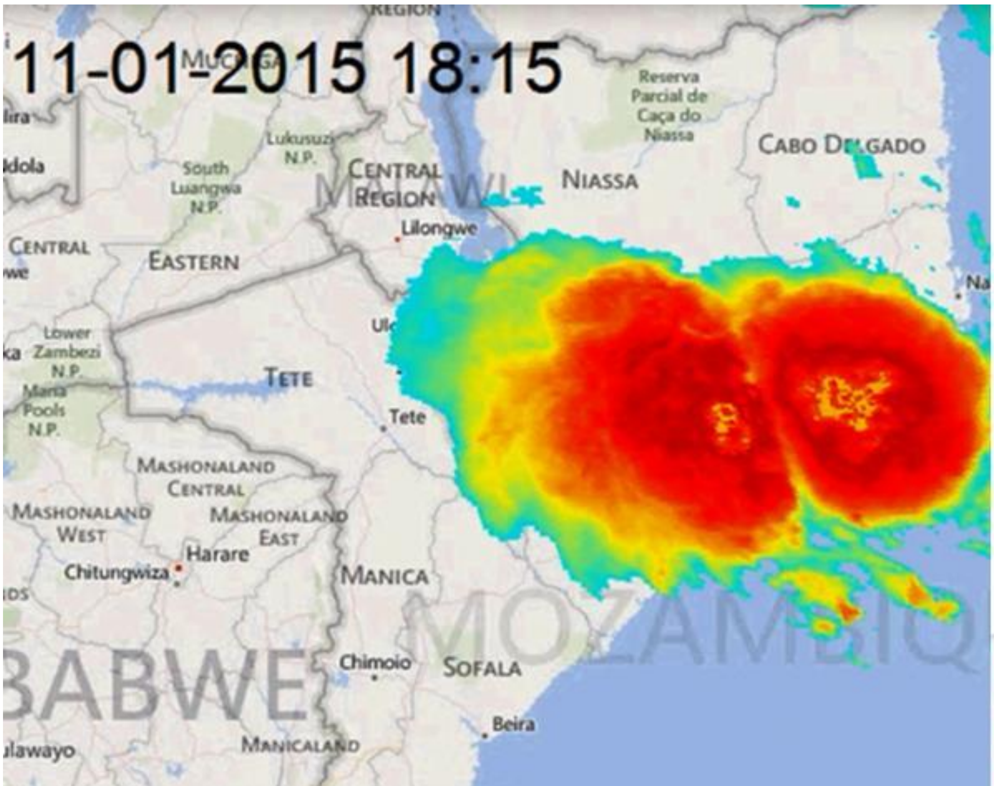


Figure 3 - Tropical cyclones Chedza and Bansi in the Indian Ocean on January 16, 2015 (source: Eumetsat, taken from WB 2015).

In Figure 4 a snapshot of rainfall quantities from January 11 is shown, where it can be seen that rainfall covered the entire Licungo River Basin and even regions beyond.



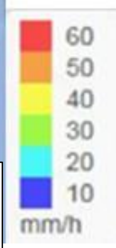


Figure 4 - Rainfall Quantities Covering the Entire Licungo Basin on January 11, 2015 (Data: Meteosat)

Based on Meteosat/TRMM data it can be deduced that between 11-13 January the entire Licungo River Basin received a rainfall quantity of about 300mm in 3 days, see Figure 5.

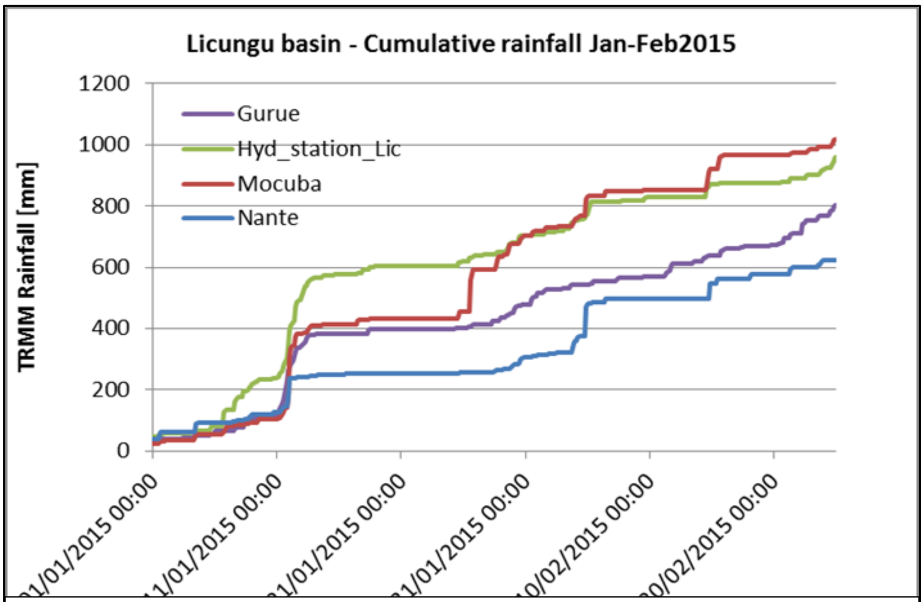


Figure 5 - Cumulative Rainfall Quantities at 4 Stations across the Licungo Basin. 11, 2015 (Data: Meteosat).

These rainfall data can be used to make a rough estimate of the discharge of the flood that occurred in subsequent days. If it is assumed that during these days all rain water volume that fell on 70% of the basin's area contributed to the river discharge at Mocuba, then an average discharge of about 19,000 m^3/s is achieved. This value is much higher than a first estimate by DNA based on extrapolation of a rating curve (stating 6,500 m3/s peak flow), and also beyond the range of 13,000-18,000 m^3/s that was estimated by a Japanese flood response mission (JICA), based on assumed water levels at Mocuba and assumed cross-section geometry and bed roughness range[1]. As the most recent estimate of 19,000 m^3/s is quite high, priority should be given to a detailed analysis and calculation to verify this figure and determine a validated result.

Next step would be to estimate a return period of the flood event, which would then indicate to which degree the dike system should be improved and how to best prepare the region for floods like these. Currently, this remains highly speculative because the flood discharge is not properly estimated yet and hence the uncertainty about the return periods would be extremely large. However, when estimating the return period of the flood event, it is important to realize that this particular event was caused by a cyclone, and should not simply be extrapolated from probabilities of the common day-by-day rainfall events[2]. Such extrapolation may lead to grave overestimation of the return period, because, unlike cyclone weather systems, "common rainfall events" are very unlikely to deliver such quantities of rainfalls. It is recommended to carry out a thorough statistical analysis of the 2015 rainfall quantities, using mixed probability distributions of historic cyclone and common rainfall events.

---

[1] Personal communication with DNA. No details of exact estimation were exchanged.

[2] See also the use of mixed distributions in "ANALYSIS OF EXTREME RAINFALL EVENTS" in "CT5450-HYDROLOGY OF CATCHMENTS, RIVERS AND DELTA'S" by H. Savenije.

3.3 Chronology of Flood (Flood Genesis)

Hydrometric data in Licungo basin is scarce, which makes it difficult the quantify the severity of the 2015 flood and to compare the 2015 flood to earlier flood events. Figure 6 shows the stage records at the only two official hydrometric stations in the basin at Gurue and Mocuba. The alert water level at Mocuba is 6m, which was exceeded on January 10 at 6.55 m and then showed an extremely rapid rise to water levels beyond 12m between January 11 and January 12. The exact peak water level at Mocuba on January 12 is unknown because the gage maximum height was 12m and was recorded as "submerged"[3].

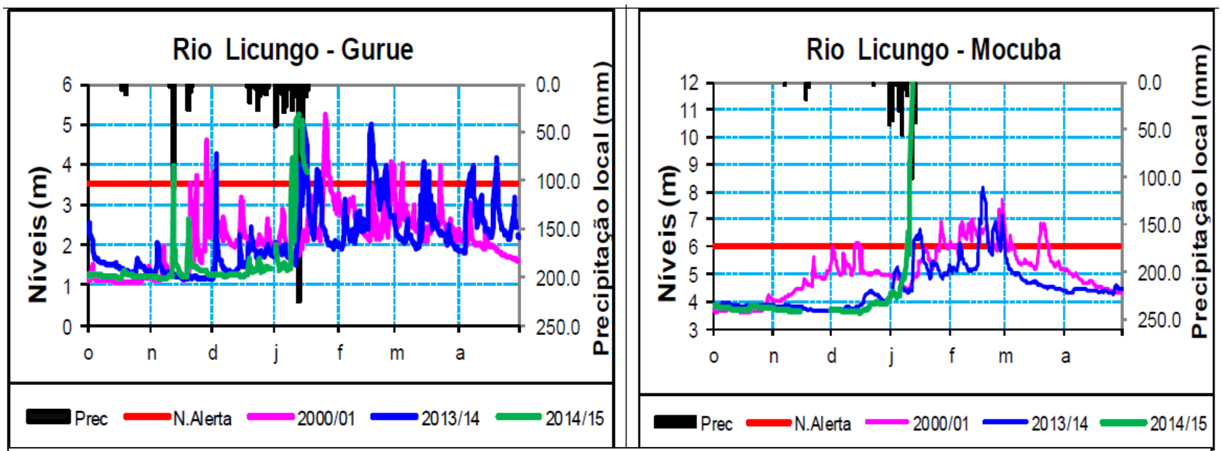


Figure 6 - Measured Water Levels and Precipitation at Stations Gurue and Mocuba (from DNA Bulletin of 16 January 2015)

The days following January 12 showed a data gap in water levels at Mocuba, which lasted about two weeks. From discussions with staff from ARA-Centro-Norte and witnesses in Mocuba and Nante it became apparent that water levels indeed reached a peak of around 12 m height near Mocuba and that this data point is not an erroneous outlier.

In Table 1 a sketch a chronology of key events and observations during the flood of 2015 is presented (See also Annex G for summary of official DNA bulletins):

Table 1 - Chronology of key events during 2015 flood in Licungo basin

Date	Observations
Jan. 9-11	• Regular water levels in the Licungo basin, sometimes approaching and slightly surpassing alert level • In the evening of 11 January: extreme rainfall events • In the evening of 11 January: bridge at Nante collapses
Jan. 12	• Continuing extreme rainfall in entire Licungo basin • Water level at Mocuba rises by more than 5m in less than 4 hrs and reaches it maximum beyond 12m • Bridge at Mocuba collapses, trapping people on bridge • Bridge at Malei overtopped and severely damaged
Jan. 13	• Continuing rainfall in entire Licungo basin (but less extreme) • Water level at Mocuba drops and at Nante the water level reaches its maximum

[3] Water levels did not go much more than 1m beyond 12m height, because according to witnesses the bridge at Mocuba was never overtopped.

Jan. 14-16	• Rainfall returns back to normal • Water levels further reduce at Mocuba and maintain their high level at Nante
Jan. 17 – Feb. 10	• Water levels at Nante remain high and fluctuate, with a trend to reduce.

From interviews with local people it followed that the flood peaked quite sharply at Mocuba on January 12, and that high waters also reached Nante the same day. The actual maximum stage at Nante appeared to occur a day later on January 13th. Water levels in Mocuba returned back to normal within several days but remained high at Nante for several weeks (Figure 7). This latter retention effect at Nante is due to the topography of the land in the lower reaches of the Licungo Basin. The land flattens out to an extended low-lying region along the coast, which is blocked off to the sea by elevated dune-ridges at the coastline. During flood events, the low-lying regions behind the coastal dunes fill up as a "bathtub" and only very slowly drain off to the sea. This effect is noticeable up to and beyond Nante (Figure 6). It is interesting to note that this low-lying region may also be flooded by water delivered from the Zambezi catchment (see Figure 2), potentially lengthening the flood duration in the region.

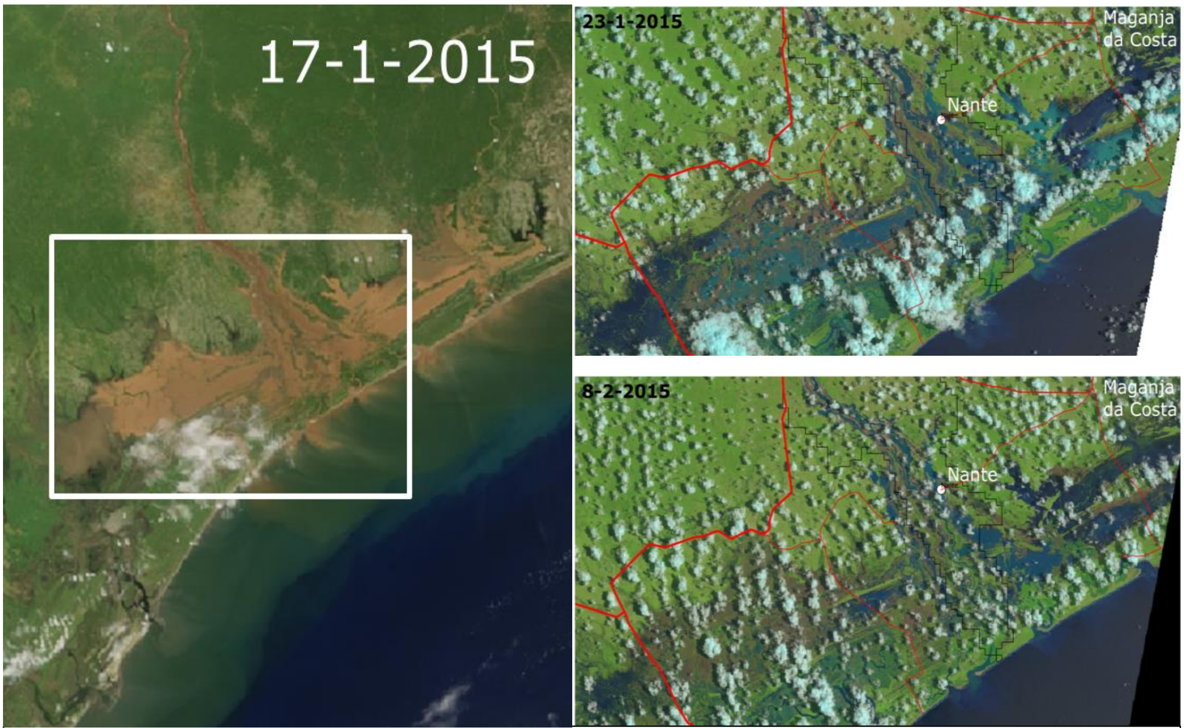


Figure 7 - Flood Extent in the lower Licungo Basin on January 17, 23 and February 8 2015. Measured Water Levels and Precipitation at Stations Gurue and Mocuba (from DNA Bulletin

Figure 8 shows that in the 2015 flood, the vast majority of flood victims occurred in the upper reaches of the Licungo Basin where the flood extents were much smaller. In interviews with INGC and locals it was confirmed that only very few casualties were registered in the Nante region. Also, in those upper reaches no dikes are present so these casualties are not related to dike failures. The true reason for the high number of casualties needs to be investigated but it most likely due to the occurrence of violent flash floods in the steeper regions, the incomplete coverage in the area flood risk committees and the lack of flood awareness.

Local	nr
Morrumbala	25
Namarroi	22
Lugela	18
Milange	13
Mocuba	10
Namacurra	10
Gurue	10
Metuge	8
Cuamba	8
Ile	6
Pebane	6
Gile	5
Mopeia	5
Mecanhelas	5
Nicoadala	2
Maganja da Costa	2

Figure 8 - Registered Casualties in the Licungo Basin during the 2015 Flood (Source: INGC) of 16 January 2015)

3.4 Preliminary Flood Hazard Maps

The DRR-Team was asked to assist DNA in the elaboration of inundation maps to better anticipate the possible extension of floods in the Licungo Basin. It is possible to construct flood hazard maps that indicate regions of varying degrees of flood risk. To construct reliable maps not only reliable hydrological data (and return periods) are required, but also a hydraulic model of the basin needs to be constructed that allows flow routing to indicate flood-prone areas. Such an effort is careful and expert work, requiring good understanding of physical characteristics of the basin and reliable statistics of hydrological events. However, using a much simpler technique also a first indication can be given of areas under flood risk. The so-called Height-Above-Nearest Drainage (HAND) methodology[4] uses only elevation data to deduce stream networks, flow directions and potential flood zones.

In Figure 9 examples are given for the Zambeze delta and the Licungo basin[5]. When comparing these maps with the satellite-detected flood extents around Nante (Figure 10) it shows that quite a good match is achieved. Therefore, by lack of a more advanced flow

[4]HAND: The drainage area is defined for each elevation cell. Next the stream network is defined based on a chosen minimum drainage area. From this the flood prone area is defined by a chosen height above the nearest drainage. The minimum drainage area that defines the stream network as well as the height classification above the nearest drainage is based on historical validated flood events. See also: Rennó, C.D., Nobre, A.D., Cuartas, L.A, Soares, J.V., Hodnett, M.G., Tomasella, J., Waterloo, M.J., 2008. HAND, a new terrain descriptor using SRTM-DEM: Mapping terra-firme rainforest environments in Amazônia. Remote Sensing of Environment, 112, pp. 3469-3481

[5] These maps were based on 30x30m grid cells (SRTM data). In the HAND procedure the stream networks were determined by searching for elevation cells were 2000 or more of the surrounding elevation cells could runoff to.

routing model, this type of hazard maps appear to give a valuable first indication of flood-prone areas.

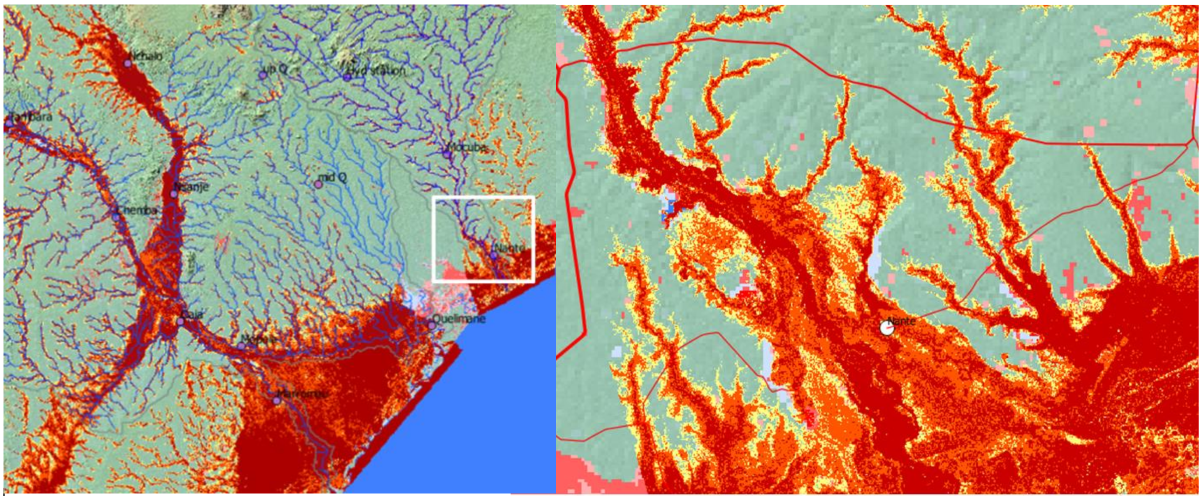


Figure 9 - Flood Hazard Maps Constructed Using the HAND-Methodology

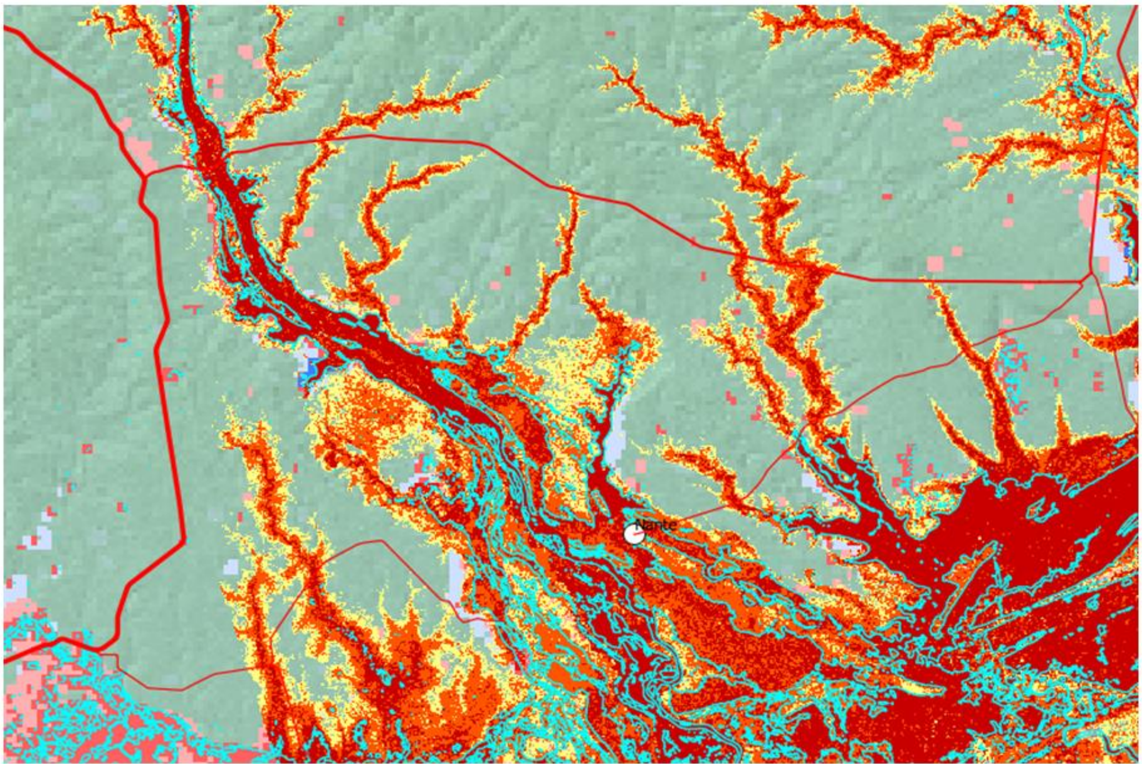


Figure 10 - HAND-Flood Hazard Map in the Vicinity of Nante (white marker) in Combination with Satellite Detected Flood Extent of the January 2015 Flood in the Licungo Basin

3.5 Observations and Conclusions from the 2015 flood

- The 2015 flood in the Licungo Basin was caused by extreme amounts of precipitation in the entire catchment, related to a (binary) cyclone event on the Indian ocean;
- During the 2015 flood the basin demonstrated an extremely fast hydrological response (<12 hrs);

- DNA bulletins are set up once a day and state the situation as recorded at 6am. Extreme events later during the day remain unregistered until the next day. Local authorities (ARA) transmit more up-to-date warnings;
- Hydrologic data in the Licungo Basin is scarce, but during the 2015 flood more hydrometric stations further upstream would have given little, but crucial, additional warning time. At the moment no automatic stations are present in the Licungo Basin;
- To make better use of the limited flood warning time available, *automatic* hydrometric stations (rainfall and hydrometrical), providing real-time data, and rainfall forecast should be installed;
- The return period of the 2015 flood is not yet known and deserves immediate attention in a follow-up study. The present estimate is that the peak discharge of the flood was 19.000 m^3/s or more;
- The drainage to the sea in the lower Licungo seems blocked in the coastal zone. Possibly Room-for-the-River strategies could be considered here;
- Casualties during the 2105 Licungo flood were dominant in the upper reaches of the basin and were unrelated to dike failures;
- Mocuba had an exceptional water level increase causing heavy damage to roads and bridges. One of the reasons that this city was hit so hard is that it is located at the confluence of the two largest sub-basins inside Licungo river basin. When the flood peaks of these rivers coincide, the resulting flood wave can become extreme;
- It appeared that the bridge at Mocuba acted as a significant obstruction to flow during the 2015 flood (as evident from backwater effect seen in photographs at the damaged bridge). During reconstruction a less hydraulically-obstructing structure is recommended.
- Also the water intake installation of AIAS was completely destroyed, requiring substantial finding for repair of the installation.

4 FIELD VISIT TO THE LICUNGO BASIN AND MARROMEU

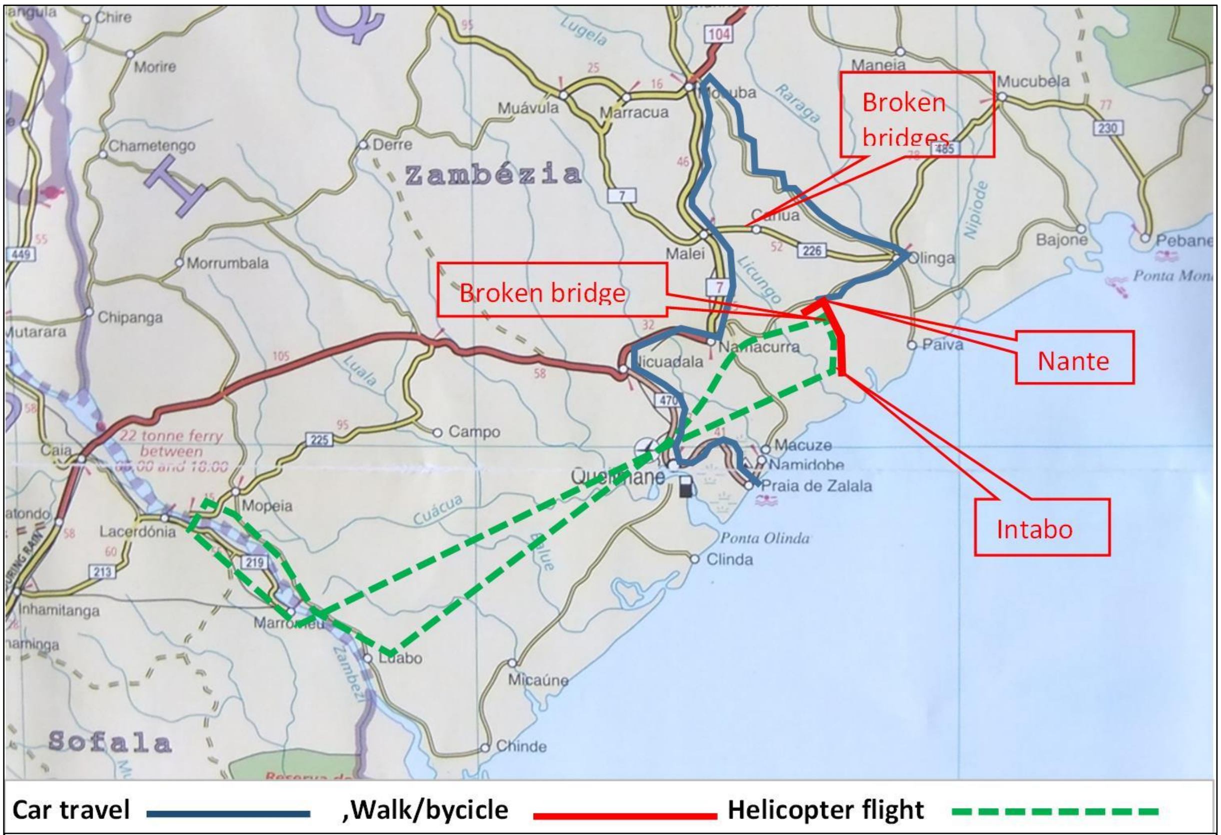


Figure 11 – Itinerary of Field Visit

4.1 Introduction

The scoping mission was set-up in little time and had a short duration period, with the number of days in the field restricted to two and a half days. Because of several broken bridges travel from Quelimane to the Licungo River and Nante area consumed many hours. A request was made to ZVDA to make a helicopter available for one day in order to be able to visit also the area of Marromeu in the Zambezi valley. The DRR-Team thanks the ZVDA for providing this huge help in overcoming time limitations. Figure 11 shows the itinerary.

The required damage assessment and repair cost estimate was concentrated on the Nante area, part of the Licungo basin. The accessibility was reasonable, accepting that the breach sites were visited on foot and by bike over a total distance of 2 x 12 Kilometres. The Nante area was visited once more by helicopter so as to obtain a global view of the damage and the layout of the existing infrastructure.

The Marromeu area was visited only by helicopter, which turned out to be an ideal means of transportation for general inspection. A courtesy visit to the local authorities was organized in Marromeu.

A selection of photos taken during the field trip of the damages to infrastructure and some brief observations are presented in Annex H.

4.2 Scale of Damage in the Licungo Basin

For the local inhabitants of the visited region the scale of the material damage is huge as it affects directly their means of living and food production. Regarding the height of the flood it was observed that in many places water level surpassed the existing dike by more than one meter, sometimes up to 2 m.

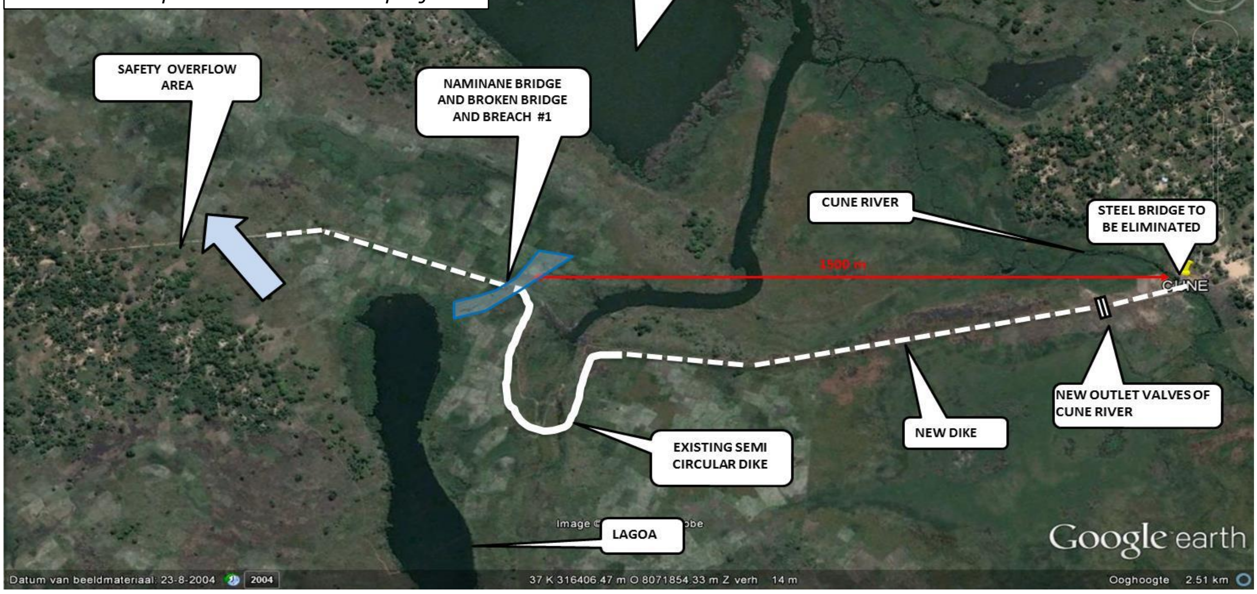
In terms of dikes, roads and bridges, in the Licungo river basin the number of dikes and their length is still limited. In general, the size of the dikes is small and the breaches are not very big with a few exceptions only. The cost estimate for the dike damage (7.7 million USD) represents about 20% of the value needed for the repairs in the Limpopo river dikes after the flood of the year 2013 (35 million USD).

The damage to cultivated areas, as seen from the air, is vast. Many of these areas were still inaccessible at the time of the mission, three months after the floods. From the air it could be seen that in general the agricultural infrastructure inside the irrigation fields (the fields, small roads and canal-dikes and bridges) was severely damaged and need rehabilitation for food production capacity. Besides the above mentioned damage, electricity posts and cables have been destroyed over long distances, which increase the isolation of the inhabitants in the affected area.

4.3 Dike Section Nante-Moneia

This dike section crosses the low area between Nante and Moneia, Figure 12, at the southern side of the Lagoa Tandamela. When not broken, the dike serves as a road connection between the higher ground of the above mentioned populated areas. At the Nante end of the section exits a Baily bridge over the Cune River which streams mainly parallel to the dike and between the dike and the lake. This dike does not lead through dwellings and has low grounds at both sides which were partly used for agriculture. The flood has deposited a big quantity of dark brown clayey sediment at the south side.

Figure 12 - Dike between Nante and Moneia and pland Munda Munda project



The straight part of the dike is lower than the horse-shoe loop that was constructed around a deep breach so as to close it in dry conditions. The slopes of this dike have an inclination varying from 1:2 to 1:3. It was observed that very little damage had occurred to these slopes. This dike was overtopped by the flood of 2015 but the difference in water level of both sides was not big, so the dike did not suffer severe erosive currents, which helped to keep the dike intact. Generally dikes will suffer erosive currents by overtopping of water flowing to low level areas. The level gauge near the baily bridge was submerged so that measuring water levels was not possible during the top of the flood. But markings were made on trees. With the aid of a topographical survey flood data can be re-constructed. Between the west side of the loop and the small concrete bridge a bigger size breach has opened, Figure 13. The place is called Naminane. The concrete bridge broke and collapsed.

Because of the breach and the collapsed bridge the connection of the road was closed. The distance covered by the team was 2 kilometres up to this breach. The team could not cross the breach (is a lake) by canoe because of government safety restrictions applicable to the DRR-Team members.

Figure 13 – Collapsed Bridge and Breach at Naminane

Important parts of the loop are covered with elephant grass that was flattened by the overtopping waters on several places. The grass has kept well during the overtopping. Also the clay cover of the dike has not suffered extensive damage. This observation illustrates the importance of using grass, combined with good quality soil on the slopes.
The local authorities have explained that projects are being prepared for irrigation purposes by which the dike will function as a dam for the storage and regulation of water (for more detail see the Munda Munda project, Chapter 5) The storage area will encompass the Tandamela lagoa and its surroundings. The dam will be equipped with outlet gates near the Cune river crossing and an overflow area at a determined level at the end near Moneia. The Cune river will be closed. Besides this function of water storage dam the dike will continue to be a road connection between Nante and Moneia-Ilima area. In the road connection between Moneia and Ilima a new sluice gate is foreseen in a new (to be built) canal from the Lagoa Tandamela.

The important road connection between Nante and Maganja da Costa needs repair and maintenance. This road is on a slight elevation but does not serve as a dike as it has various culverts to pass the high waters from the Lagoa Tandamela. Also the road Niquide – Nante should be repaired to enable the start of the Munda Munda/ORIO project

(Info Jan de Moor). Topographic surveys should be executed so as to know the dike, structures and field levels.

4.4 Dike Section Nante-Intabo

Between Nante and Intabo a dike exists that is sometimes a river dike protecting habitat, sometimes a road, sometimes agricultural land and sometimes all of these. This dike, Figure 14, runs over 10 kilometres, mostly parallel to the Cune river on the left bank or at a slight distance from it. Over the second half the dike flanks the Licungo river. As a road it connects the village of Nante and Muguloma and Morla. The last part towards Intabo does not seem to be used by cars, only by bicycles and pedestrians.

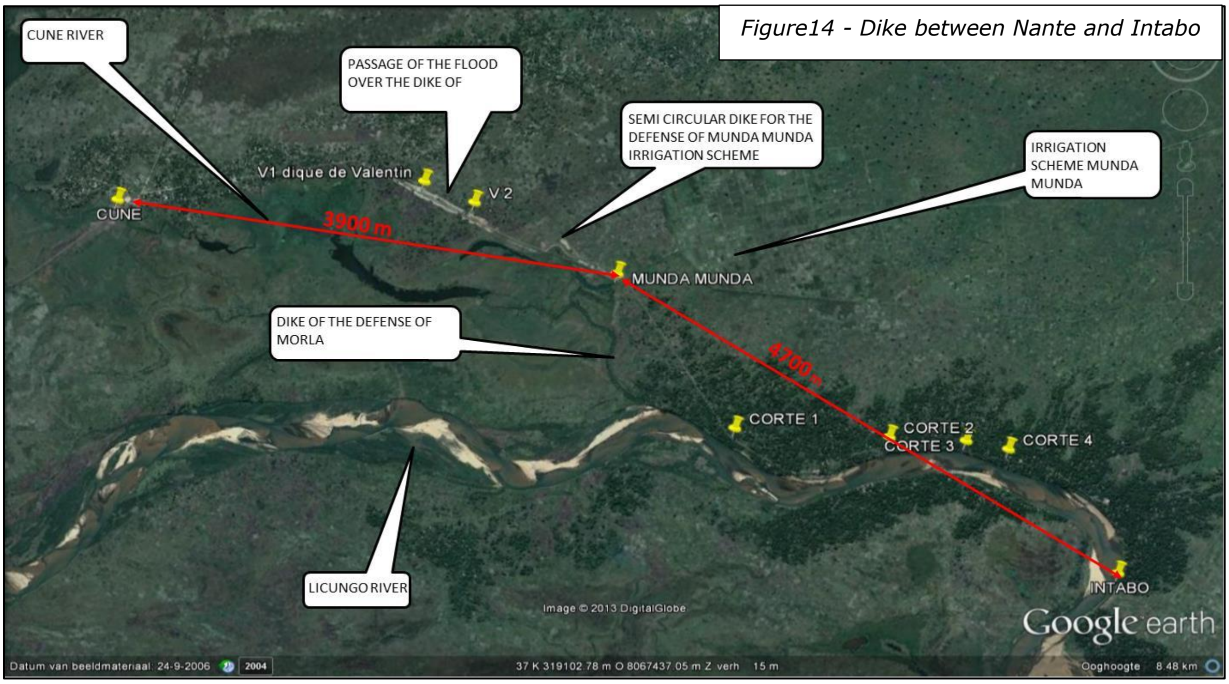


Figure14 - Dike between Nante and Intabo

The construction of the dike where it is also a road is rather low and in various places it is interrupted by small bridges over natural drains and irrigation canals. To re-install the road connection a major part of its length has to be re-fitted with a top layer of compactable soils. The above is also necessary for the dike part that serves both a river dike and road.

The dikes that serve as protection and do not have a road function have rather steep slopes and carry different types of grasses that have a protective effect on the slope. Nevertheless the floods of the year 2015 have severely damaged these dikes in several places. Both, river dike and dike road sections have been submerged by the floods by almost man-high water levels.

4.4.1 Locations of Special Interest

Eribacila

The Eribacila weir is situated in the Cune river, see Figure 15, a short distance downstream from the Munda Munda intake structure. The function of the weir is to provide sufficient hydraulic head to enable gravity flow to the Munda Munda irrigation scheme. The weir consists of a concrete barrier at a chosen level with gates in the concrete structure to discharge the water flow in case of high water levels. Both sides of the weir have wing walls downstream and upstream of the barrier. The weir and surrounding were totally submerged by the floods of 2015. This place was not visited by the DRR-Team because of difficult access conditions.

Figure 15 – Eribacila Weir in the Cune River

The aerial photographs show clearly that the dam has suffered extensive damage and that a huge quantity of soil has been removed from the left bank by the floods. A section of the dike on the left band (outside curve) over a distance of 270 meters has disappeared. As one can see there is no space to dig big quantities at the side of the structure because the material has already gone, so the material necessary to fill the holes and to repair the dike have to come from farther away (from a place close to the semi-circular loop not far from Nante, distance about 1,5 Km). Also the wing wall and its foundation will need repairs (see also the cost estimate). In the cost estimate the dike and the soil lost at the side of the weir have been included (Items 31-34). Also the repair of the road has been taken into account (Items 25-30).

Intabo

The Intabo intake structure, see Figure 16, serves a vast irrigation scheme. The structure is located in the outside curve of the Licungo River, where the current of the flood waters has a heavy impact on that left bank representing a high risk of erosion. This led to the rupture of the downstream dike over at least 150 meters (Item 60 of cost estimate) and a big influx of water (actually a "new" river) into the irrigation scheme behind the dike, see Figure 17. As the new river blocked the access to the rest of the dike the DRR-Team was forced to stop here and return to Nante. The soil necessary for the restauration of the dike is not locally available and has to be taken from a place close to the semi-circular loop not far from Nante, distance about 6.5 Km. Topographic surveys should be executed in all areas so as to know the dike, structures and field levels.

Figure16 – Details of Intabo Area

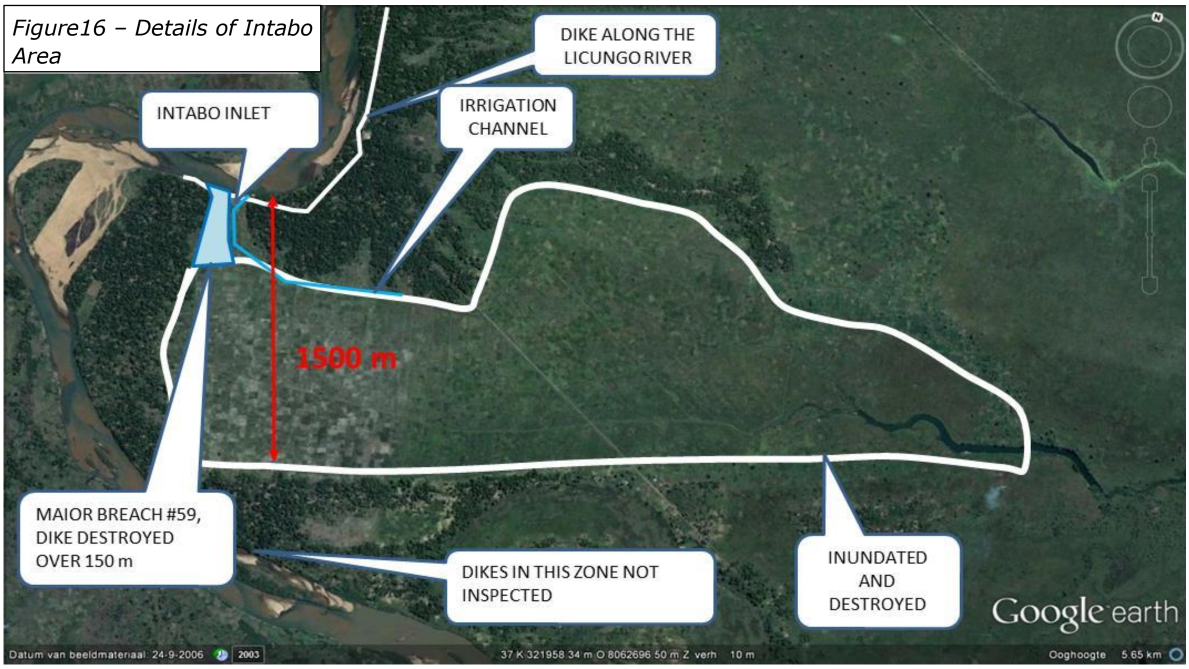


Figure 17 – Intabo Intake Station, Canal and Breach

4.5 Consequences of the 2015 Flood for Munda Munda Project

As part of the mission to the Licungo basin, and at the request of the Royal Netherlands Embassy, particular attention was given to ongoing and future plans in the Munda-Munda project. This project is of immediate importance to the well-being and prosperity of the region as it provides the largest single agricultural area in the Licungo basin. During the 2015 flood, the hydraulic infrastructure of the Munda Munda irrigation area was destroyed. Considering the much higher than expected flood levels, a rethink is required on the proposed design of the new gravity feed irrigation infrastructure, and the optimum, economically feasible, dike design.

A detailed description of the Munda Munda project area, the planned modification of the hydrological system to enable gravity-fed irrigation, the state of the area after the floods and the proposal for an adjusted time-frame to enable an analysis and final design of the infrastructure is presented in Annex I.

4.6 Dikes in the Marromeu Area, Zambezi Valley

The dikes in the Marromeo area have a long history. The building of the village dikes started in the period when the SENA Sugar Company was formed and served for the protection of the SENA workers. At that time SENA was a private company. Later the company became a state company and after the civil war it became private again. During those changes in management and status the responsibility for the building and maintenance of the dike protecting the workers was not clearly defined and to this day discussions exist whether or not these village dikes fall under the responsibility of the village (Municipality) or the SENA Company. The result is that the village dikes are not being maintained and have fallen in disrepair. The dikes protecting sugar cane plantation are generally well maintained by SENA.

Many of the dikes, as seen from the air, are covered with thick vegetation which does not show major breaches and damage due to the recent floods. Under the grass however, depressions and damage by earlier floods may be hidden. It is recommended that the responsible authorities organise detailed inspections along all dikes on foot and note all relevant breaches, depressions, slope conditions, crest conditions, presence of grass, trees, cultures on the slopes, habitat at the sides of the dikes, so as to obtain a complete image of the dikes that may serve for estimating repairs. Topographic surveys should be executed to know the dike, structures and field levels. No damage reports were shown. Because of the limited time and the extent of the dikes it is strongly advised to proceed with such inspections as soon as possible.

In the Luabo area, abandoned fields, dikes and buildings have been observed from the air. Dikes are overgrown by greens. No major breaches were observed. They may be covered by greens, indicating that possibly existing breaches may be the result of earlier floods. Extensive surveys need to be carried out. In the Mopeia area poorly maintained fields and dikes were observed from the air. Extensive surveys need to be carried out.

Annex J presents a summary on observations concerning present practices of dike repair and maintenance, responsibility issues, slope protection, recording on dike conditions and mapping and procurement procedures.

4.7 Cost Estimate Based on Field Inspection Visit

Annex K presents a table with a detailed summary of the inspection of the dikes at Nante for which a cost estimate was requested by DNA. In an earlier mission by the WB a preliminary estimate was presented based on a unit price of 50 USD per m3. For comparison reasons the same unit price has been used. A total of 50 sites were visited and dimensions of the breaches estimated. An additional 12 sites were estimated based on the information of the local resource person, Jan de Moor.

The total cost for the earth works, excluding the additional of mobilisation, is estimated at 7.7 million USD, including contingencies of 20%. This total is 14% higher than the original WB estimate based on a general assumption of 30% losses over the total length of dikes.

5 RESULTS AND FINDINGS

The Licungo Basin is a relatively unspoilt, natural river basin. There is a limited number of dikes in the lower flood plains so the river flows more or less unobstructed through the basin in a natural system. At the same time, the fertile flood plains in the Licungo Basin offer substantial potential for the development of irrigated agriculture. Dikes which are constructed close to the river to keep the water out of the agricultural areas will however impact on the discharge capacity of them. In times of floods the loss of retention capacity will lead to strongly rising water levels, eventual loss of lives, destruction of infrastructure and major loss of income.

In the Licungo Basin there is still great opportunity to look for the ideal combination of developing agricultural production in the floodplains while using the same area for the storage of flood water in case of extreme events. This requires a different embankment system which serves both the river and agriculture. The principle is to design and select a certain flood protection level, economically justifiable, and high enough to experience overtopping, and subsequent flooding, possibly only every (5), 10 or 20 years. At the same time, the new dikes need to be designed robust enough that they withstand overtopping without major damage, e.g. slopes of the downstream side of dikes gentle enough to reduce water velocity and turbulence with strong, covering vegetation.

Also specific measures must be implemented to protect people, harvested crops and seeds by constructing a number of elevated emergency areas. Also the robustness of the irrigation infrastructures needs to be investigated. It has to be studied why pumping stations were damaged and what can be done to provide a robust functioning of these.

This development approach requires strengthening of the coordinating mechanism between DNA, ARA Centro-Norte, ZVDA, MITADER and INIR (see also Chapter 5, "Integrated Flood Management for the Limpoppo Basin in Mozambique – Scoping Paper, February 2014).

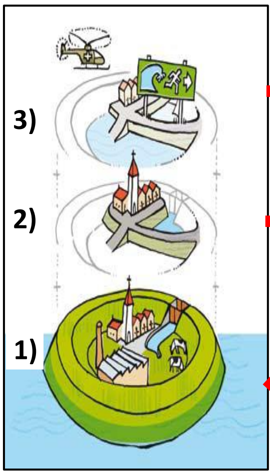
5.1 Flood Management and Water Management

The Dutch approach to flood management finds increased acceptance, as was apparent in DNA's presentation of their Action Plan for the Mitigation and Prevention of Floods. The Flood Safety Strategy to achieve the flood management goals is based on three components of protection; see Figure 18, which are also relevant to the Licungo Basin:

1) Flood prevention: protection by hard defences - dikes, embankments, barrages;

2) Flood-proof spatial planning, with measures in flood mitigation and flood adaptation;

3) Disaster management, early warning and flood modelling.



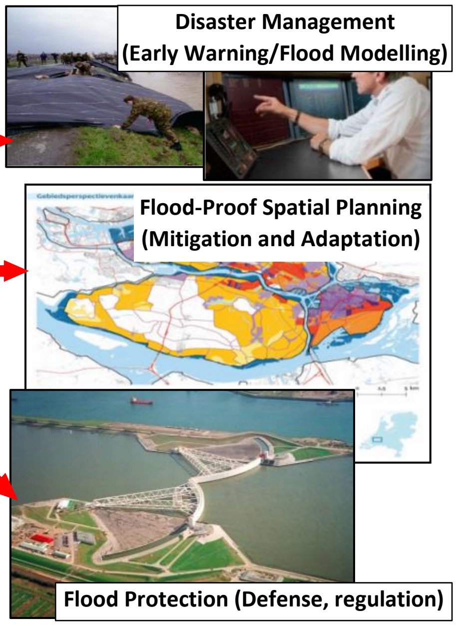


Figure 18 - Triple-level Safety Policy

Component 2, Flood-Proof Spatial Planning (mitigation and adaption of floods) is still a real challenge in Mozambique as it requires integral solutions: cooperation between all stakeholders, and solid water management practices embedded in sound political, legal, social and financial arrangements.

5.2 Water Governance

An integrated approach to flood and water management requires the involvement of all stakeholders to create integrated solutions. The exchange of information between the water-relevant parties is not routine practice in Mozambique. The plans by INIR on agriculture in the basin, the socio-economic development planning being carried out under the PEOT (Special Plans for the Spatial Planning of Zambezi Province), and the plans of road and bridge development (ANE and Railway authority) are not yet sufficiently cross-examined on their effects on the hydraulic regime in the river basin and flood plains.

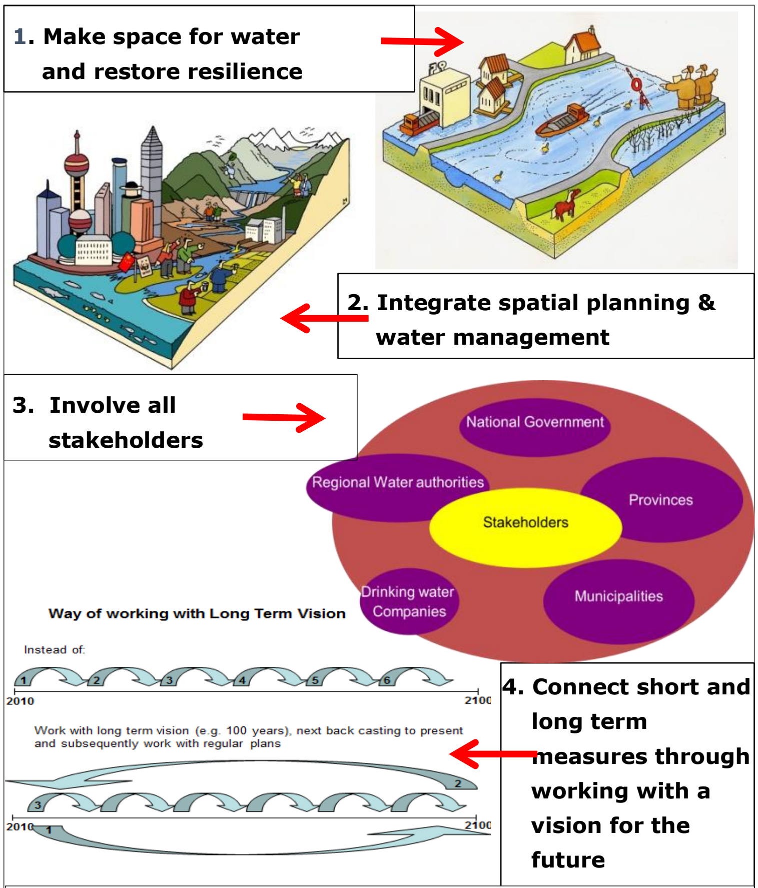


Figure 19 – How to become more climate proof?

Figure 19 shows the essential measures needed to make flood plains more climate proof. All measures require coordination, cooperation and discussion between all parties with a stake in the socio-economic development of the basin nd are part and parcel of **water governance**. They are:

1) Making more room available for rivers to restore resilience;

2) Integrating spatial planning and water management;

3) Involving all stakeholders;

4) Connecting short and long term measures through working with a vision for the future.

5.3 Stakeholders and Integral Solutions

An important and positive development in this mission was the participation, besides DNA and the ARAs, of INGC, MITADER, ZVDA (who made the helicopter available for the dike inspection) and especially INIR, both at national and at provincial level, to represent the interests of agriculture and irrigation in the socio-economic development of the Licungo Basin. Flood control and the development of agriculture are closely linked as it is about the physical occupation of the flood plains and the regulating structures protecting lives and goods. The phenomenon of floods is also highly significant for ANE (the National Roads Administration, of the same Ministry of Public Works, Housing and Water Resources), LFM

(Railroad Authority Mozambique) and the Ministry of Energy (power lines) as the major damage of the floods was in roads and especially bridges and the design of bridges in flood plains needs sufficient capacity to pass flood currents.

At the start of the DRR-mission DNA presented a summary of the actions that were initiated after the floods of 2013 in the Limpopo and Zambezi Basins (see Annex L, Literature). These actions include an analysis of the staff needed, the improvement of communication between DNA and the ARAs, the elaboration of basin plans for the Limpopo and the Zambezi, actions for financing and increasing operation and maintenance of reservoirs, a redesign of the alert levels and a number of feasibility studies on flood mitigation measures.

Furthermore, DNA presented a paper on strategic actions for the mitigation and prevention of floods and a vision on which steps to take. Part of the vision is a National Flood Plan, the creation of a Unit within DNA to monitor and implement actions, the improvement of the inter-institutional coordination and the increase in investments of the early warning and flood modelling instrumentation (see Annex L).

5.4 Needs

As far as the needs are concerned, the WB/UN/EU damage assessment report estimates the total damage of USD 371 million which represents about 2.4 % of the GDP of Mozambique. With a figure of USD 155 million, most of the flood damages have been attributed to roads and bridges. Damages to dikes were estimated at USD 6.7 million. In the agricultural sector, damages were assessed at US$ 81 million on crops, USD 14.2 million on irrigation infrastructure and USD 0.3 million on drainage infrastructure.

The DRR-Team was asked to inspect the state of the dikes near Nante and Marromeu to confirm the earlier estimates by the WB. As the time to the next flood season is very short, there is only time to repair the dikes to the level as was before the floods, providing a minimum standard of protection. So the cost estimate of USD 7.7 million (excluding the cost for mobilisation of equipment) that the DRR-Team presents here does not include the urgently needed improvement in resilience, such as decreasing the dike gradients to slopes which allow overtopping and provide a higher level of protection against floods.

In the agricultural sector damages were estimated at USD 81 million on crops and USD 14.2 million on irrigation infrastructure, which includes the Munda Munda irrigation area near Nante that was subject, as in 2013, to heavy damage and destruction of the hydraulic infrastructure.

These losses are not sustainable and real socio-economic development can only take place if after early recovery, a post-flood rehabilitation phase is initiated that includes structural and non-structural measures, including flood proof spatial planning, flood mitigation measures giving room to flood flows, such as widening the bridge openings, making dikes more resistant to overtopping and adaptive measures to reduce losses by inundations. For these and similar initiatives, there is an urgent need to develop a vision on how such irrigation areas should be provided with an economically acceptable infrastructure for flood protection.

Integral solutions are key, which requires, as indicated earlier, a close cooperation between all parties involved and sharing the financial burden for a sustained economic recovery. The investment needed for this kind of approach will be substantially higher than the direct associated costs of repair “as is”. DNA and the ARAs need to play a proactive role in assisting the other water-affected sectors in coping with and reducing vulnerability against floods.

As far as non-structural needs are concerned, for better water management and flood protection, safe road construction and bridge design and flood-proof irrigated agriculture, foremost studies are required to determine return periods of the recent floods, the establishment of sensible, economically viable, protection levels and dike design and strengthening of the information and knowledge management among government agencies at national and provincial level.

5.5 Financial and Economic Assessment

Development Potential

In the Licungo Basin there is a good potential for agricultural and irrigation development, particularly for rice and tea. Forestry and pulp industries are also being planned for this river basin. The Licungo floodplain downstream of Mocuba is primarily used for subsistence agricultural production but there is also a good market for an increased production of rice, as Mozambique is importing rice to supplement it needs.

The yearly rice shortage in Mozambique amounts to 400,000 tons, requiring an additional 30 to 60 thousand of ha of agricultural land to be developed for rice cultivation, depending on crop patterns applied. Currently, a 3,000 ha irrigation scheme is under development at Munda Munda, just downstream of Nante. With an expected yield of 3 tons per ha, the rice to be produced in Munda Munda is seen as a biologically friendly product.

For the right bank Lower Licungo project (Namacurra District), an investment opportunity is being prepared for the first DRIVE call later this year for the development of 5,000 ha of land for the irrigation of rice. INIR will be the owner and will negotiate an AdB loan, while the Dutch RVO.nl will facilitate the process with additional funds and services. For RVO support however, a Dutch company must be one of the participants. So it is necessary to raise the interest of Dutch companies to participate in organizing the rice value chain for the Mozambican market (import substitution) for 80% of the production and to open an export line to Europe with organic, aromatic and fair trade rice (a new product) for the remaining 20%.

Related to this is the negotiation of a management contract with the Mozambican Government for the use of the (Chinese) rice mill at Namacurra.

Enabling Conditions

An important condition for the planned expansion of irrigated agriculture and associated increase of produce is the ability of transporting agricultural products out of the area to markets. Along with an increase in agricultural production the road networks needs to be improved; most urgently the bridges should be able to withstand the flood torrents so that transport is guaranteed. There is an urgent need to check the design of the major bridges and establish the peak discharge return period for the (re)design of these bridges.

6 RECOMMENDATIONS AND PROPOSED FOLLOW-UP ACTIVITIES

6.1 Strengthening Water Governance for Integrated Solutions

Often, a water management crisis is also a (water) **governance** crisis. Not only technical expertise ("hardware", structural measures) is needed to solve water-related problems, but also knowledge on the organisation of water management and the way it is embedded in political, legal, social and financial arrangements ("software", non-structural measures). The techniques for water management and flood control are generally available but bottlenecks often are related to governance challenges such as institutional fragmentation, lack of systematic planning and solid financial systems.

It is **strongly recommended to strengthen "Good Water Governance"[6] practices** in Mozambique as an important overarching theme for increasing water security, water safety and sustainable economic development. Governance focuses on the institutional, legal, administrative, financial and economic capacities of all stakeholders including the governmental ones, and on communication between and participation of all stakeholders, taking into consideration the social necessities of the society (be it on national, regional or local level).

Integrated solutions are necessary which demand a true and effective cooperation between different sectors. As regards *water* governance it is recommended that DNA and the ARA's **take the lead in this process** to strengthen the mechanism of intersectoral coordination. The specific recommendations following from the DRR-Team are both structural and non-structural.

6.2 Structural Measures

The Licungo River has a dense tributary network and the road system in the basin has numerous bridges. The financial damages stated in the WB/UN/EU report show that 75% of the total direct damage is related to bridges which both have (partly) collapsed and where the access roads and their connection to the bridge have been destroyed, caused by overtopping. The destruction and overtopping is most likely caused by the restriction of the bridge abutments and access roads on the river cross section to pass flood peaks.

Considering the scale of the damage high priority must be given to the post-disaster reconstruction of bridges and access roads and to make them less vulnerable against floods. High priority should be given to the determination of the return period of the 2015 flood as basis to the design of the bridges to be reconstructed. Expectation is that the present Mocuba Bridge openings have been under-designed. This approach requires the intense cooperation between DNA, ANE and MITADER.

The following measures have been identified:

I First priority is to urgently **repair the dikes near Nante**. Considering the fact that the next flood season is only 6 months away, a phased approach is recommended. In phase 1, there is only time to repair the dikes with the same cross-section and up to the same level as before the floods. No-regret measures should be included such as improving the protection of the downstream side of the dikes with flow-resistant vegetation as to minimise erosion by overtopping. It is recommended that DNA

[6] Most of the text is quoted from "Building Blocks for Good Water Governance" by Herman Havekes, Maarten Hofstra, Andrea van der Kerk, Bart Teeuwen, Water Governance Centre, The Hague, 2013

defines the TOR and arrange financing for the contracting of dike repair works at Nante as soon as possible and start repair work in August, at the latest on September 1, 2015;

II In phase 2, as the building back of the dikes is not a long term sustainable solution given the effects floods have on the present design, **the embankment system should be redesigned**. This will probably involve substantial earth works, and possibly relocation of embankments to allow for sustainable agricultural development. Such more robust design implies the capability of dikes to being overtopped during more extreme floods. Final recommendations depend on careful analysis and study so phase 2 is not foreseen until spring of 2017;

III High priority should also be given to the further **rehabilitation of Mocuba bridge**, which has been temporarily been repaired before the next flood season. In the medium term detailed analysis is necessary to establish the required bridge span and openings to withstand peak floods as the present bridge is probably under-designed, this in close cooperation with ANE.

6.3 Non-Structural Measures

IV DNA is currently procuring the Licungo Basin Water Resources Development Plan (LWRDP). This water management plan will indicate the direction in which agriculture and (processing) industry will develop in the basin and indicate the most promising investment locations. The discussion on flood protection levels for the areas to be developed, keeping in mind future adaptations in the agricultural sector is not sufficiently addressed in this plan. The DRR-Team recommends linking the outcome of the LBWRDP closely with the further necessary **studies on flood management and agricultural development**;

V DNA is advised to carry out a study to **determine the return period of the 2015 floods** and earlier floods as to provide basic information for the redesign or reconstruction of bridges and to provide input to design of the embankment system to be developed for agricultural expansion;

VI It is recommended that the **cause of the Licungo flood fatalities** be investigated. INIR should investigate these as most of them occurred in the upstream areas and which were not due to dike failures, in order to improve early warning procedures;

VII It is recommended that DNA, supported by the Dutch Technical Assistance project which is supposed to start in June 2015, prior to the Licungo Basin Flood Management Plan (LBFMP), develops a **pilot hydrological and hydrodynamic model of the Licungo Basin**. So far, there is a severe lack of data for the development of a good model. However, the development of a pilot model will provide guidance to the further definition of data needs allowing the calibration of more precise models. It can be set up relatively quickly on the basis of the NASA SRTM DEM and best information currently available on land use and river cross-sections. As part of this activity DNA should execute a low density cross-section survey program, around August – September 2015, to provide more insight into river conveyance capacities. The pilot model will also provide a better insight into the return period of the 2015 flood. The Pilot Model should, in particular, study the relation between sustainable agricultural production and the height of protecting dikes, providing enough space for flood water retention to give guidance to the implementation and design of the Munda Munda irrigation project and other projected irrigation developments. The pilot model may also serve as a first tool to be used in the development of a flood early warning system to provide information to the Local Disaster Risk Management Committees;

VIII The DRR-Team recommends the **elaboration of a Licungo Basin Flood Management Plan study (LBFMP)**, which compliments the LWRDP. The TOR for a flood management plan should be drafted as soon as possible, during the Inception Phase of the LBWRDP. The impact of climate change should also be part of the study. Apart from changed impacts of rainfall, the low lying area between Nante and Mozambique Channel will be affected. The IPCC Fifth Assessment Report indicates a sea level rise of 40 to 100 cm by the end of the 21st century. Such rise will have an impact on Licungo River and its dikes downstream of Mocuba;

IX In order to implement the Munda Munda Irrigation project in a sustainable way it is necessary to determine the **resilient design of the embankment system and regulating structures**. Close collaboration with INIR and the provincial departments is required to arrive at agreed feasible return periods and related dike height in combination with more resistant dike slope sections to withstand overtopping during bigger floods. In order to limit the delay in the implementation of the Munda Munda project the pilot model will be extended into more detail to facilitate final design of the project, aided by additional information becoming available from the LBFMP;

X Using the results of the pilot model, it is recommended that a preliminary hydrological analysis is made to determine the optimal **openings of Mocuba Bridge** (most probably under-designed at this moment) to reduce the flood vulnerability and future destruction. More attention should also be given to the improvement of the robustness of the access roads and the connection to the bridges, to reduce the severe erosion during overtopping of the embankments. Attention should also be given to the water intake of AIAS which was destroyed during this flood;

XI There is an urgent need to **re-establish some of the old hydrometric stations** in the tributaries but also in the main stream of Licungo River, most of which have been abandoned, based on the outcome of the pilot model. In old files from before 1980 the cross-sections of these stations can be found. Also the hydrometric office in Mocuba needs urgent upgrading in terms of working conditions and security of historical data. ARA Centro Norte needs urgently financial inputs to realize these upgrading activities. Without improved data monitoring, modelling will remain a very doubtful activity. ARA Centro Norte has been requested by the developers of the Munda Munda project to re-install hydrometric stations along the Lower Licungo River;

XII It is recommended to analyse and **improve the hydro-climatic monitoring network in the Licungo Basin**, in particular the need for some automatic stations;

XIII It is recommended to **strengthen capacity in DNA in the use of real-time satellite information in flood early warning modelling and prediction**.

XIV It is recommended to carry out a **nation-wide** preliminary **mapping of flood risk areas**;

XV In the longer term Mozambique needs to **establish flood management plans for all relevant basins**. It is recommended to execute a **preliminary nation-wide survey** of flood vulnerability of major infrastructure, such as dikes and embankments, irrigation infrastructure, road and railway bridges and power lines, in close collaboration with the relevant sectors. Eventually, the flood management plans will present, among others, the hydraulic boundary conditions for rehabilitation of existing structures and design of new ones;

XVI Presently institutions, donors or governmental agencies are introducing different flood models and decision support systems as part of their assistance to DNA in relation to flood management, so different models are in use in different basins. The operation and maintenance of different systems is costly and there is insufficient capacity to maintain knowledge on all systems in the different regions and ARAs. It is recommended that DNA carry out analysis of the flood models and decision models and coordinate and **rationalise the model suite used in the water resources management and flood management**;

XVII It is recommended that DNA and the ARAs take in hand the **strengthening of the planning processes between the water-relevant sectors**, such as agriculture, energy, transport corridors (roads and railways), urban and rural planning **to achieve integrated solutions** for flood risk reduction. This entails the promotion of good water governance among the socio-economic development sectors mentioned above.

6.4 Timeline Proposed Measures and Follow-up

Table 2 gives a timeline and planning of the structural and non-structural recommendations. The costs are estimates and need to be confirmed.

Tabe 2 Recommended Short and Medium Term Activities

		Activity	Who	Cost m$
		Year: 2015 (months 6–12), 2016 (months 1–12), 2017 (months 1–8)		
		At the Level of the Licungo Basin		
I	1	Preparation TOR emergency repair dikes near Nante	DNA	
	2	Procurement and selection of contractor	DNA	
	3	Emergency repair of dikes near Nante	Emp	7.7
II	4	Resilient design and final rehabilitation of dikes near Nante	DNA/INIR	7.5
III	5	Further rehabilitation of Mocuba bridge before next flood season	ANE	n/a
IV	6	Procurement Strategic Water Resources Dev. Plan Licungo	DNA	
	7	Elaboration of the Strategic Water Resources Dev. Plan Licungo	Cons.	1.0
V	8	Study and analysis return period of floods Licungo	DNA	p.m.
VI	9	Analysis cause flood fatalities in the Licungo Basin	INGC	n/a
VII	10	Definition of a Pilot Hydrodynamic Model of the Licungo	DNA	
	11	Elaboration of Pilot Model	DNA	0.2
VIII	12	Preparation TOR Integrated Flood Management Plan Licungo	DNA	
	13	Procurement and selection consultant	DNA	
	14	Elaboration of the Integrated Flood Management Plan	Cons.	1.0
IX	15	Advise INIR on adaption river works and infrastr. Munda Munda	DNA/INIR	0.2
X	16	Preliminary hydrol. analysis conveyance capacity Mocuba bridge	DNA/ANE	0.1
XI	17	Re-establishment of old hydrometrical stations in the Licungo*	ARA-CN	1.0
XII	18	Analyse, improve and implement hydro-climatological network*	DNA/ARA	0.4
		At the National Level		
XIII	19	Capacity building use of satellite information for early warning	DNA	p.m.
XIV	20	Nation-wide mapping of the flood hazard areas	DNA	p.m.
XV	21	Preliminary analysis of flood vulnerability of major infrastructure	DNA	p.m.
XVI	22	Rationalise the model suite on water and flood management	DNA	p.m.
XVII	23	Strengthen inter-sectorial planning for integrated solutions	DNA	p.m.
		* = rough estimate only, needs to be confirmed		19.1

The indication "n/a" in the column "cost" signifies that these are costs not under the responsibility of DNA. It is proposed that the activities indicated by "p.m." are carried out in DNA in cooperation with the Dutch Strategic Technical Assistance Project due to start in June 2015.

6.5 Investment Opportunities and Financing

There are urgent investment needs, opportunities for consultants for execution of studies and commercial opportunities in agriculture.

Bankable Projects

The tendering of urgent actions under Activity I (rehabilitation of dikes at Nante) has already been undertaken by DNA and the LBWRDP financed by DNA is already in procurement (Activity IV)

From the **World Bank** side (ref. AID Memoire Flood Rapid Assessment Licungo River, Mozambique, P155440, Adri Verwey, June 2015), various initiatives could be taken to investigate financing options for technical assistance and flood management works in Licungo Basin. The needs are:

- Flood Management Plan for Licungo Basin (LBFMP), Activity VIII;
- Re-establishment of the hydro-meteorological network, Activity XI ad XII;
- Resilient design and final rehabilitation of the existing dikes at Nante and Marromeu, Activity II;
- Construction of upstream reservoirs, new dikes, diversion canals, improved roads, etc., as follow-up results of from Activity VIII;
- Resilient design and final rehabilitation of the bridges crossing Licungo River at Macungo and Malei. follow-up of Activity X.

From the **Dutch Government** the initiative could be taken to finance the development of the pilot hydrodynamic model of the Licungo as precursor to the LBFMP and advise DNA in the necessary fieldwork activities such as a river cross-section survey programme. This activity could be part of the 2-year Dutch-financed Strategic Technical Assistance programme starting in June 2015. This would provide the basic information to initiate Activities V, IX and X.

Activities XIII – XVII are national, strategic actions which will be worked out further in the Dutch TA programme.

As regards governance the Dutch government could take the initiative to increase support for the implementation of governance as an essential feature for effective water and flood management. This could be undertaken as component of the broader water programme in Mozambique (Ref: Multi-Annual Strategic Plan (MASP) for the period 2014-2017).

Consulting Opportunities

A number of consulting opportunities are foreseen: the Licungo Basin Flood Management Plan, the resilient design of the embankment system near Nante and the final design of the Mocuba and Malei bridges. In the course of the next few years other needs and priorities will be identified in securing major infrastructure in Mozambique from floods, including a numer of feasibility studies.

Commercial Opportunities

Currently, a 3,000 ha irrigation scheme is under development at Munda Munda, with financial input for RVO-ORIO fiinds, just downstream of Nante. With an expected yield of 3 tons per ha, the rice to be produced in Munda Munda is seen as a biologically friendly product.

For the right bank Lower Licungo project (Namacurra District), an investment opportunity is being prepared for the first DRIVE call later this year for the development of 5,000 ha of land for the irrigation of rice. INIR will be the owner and will negotiate an AdB loan, while the Dutch RVO.nl will facilitate the process with additional funds and services. For RVO support however, a Dutch company must be one of the participants. So it is necessary to raise the interest of Dutch companies to participate in organizing the rice value chain for the Mozambican market (import substitution) for 80% of the production and to open an export line to Europe with organic, aromatic and fair trade rice (a new product) for the remaining 20%.

Related to this is the negotiation of a management contract with the Mozambican Government for the use of the (Chinese) rice mill at Namacurra.

7 ADDED VALUE OF DUTCH EXPERTISE

7.1 Dutch History of Flood Control

Flood control in The Netherlands has a long history. More than 2,000 years ago the early settlers ***adapted*** to regular flooding by building "terps", elevated areas upon which shelter and storage facilities were built, see Figure 20. Then came the formation of water boards in the middle ages where people organised themselves in the fight against water. Advances in technology led to the age in which hard flood defences were built, culminating in the construction of the Delta Works, finished in 1985, leading to the "belief" that any water threat could be dealt with technologically by "hard" defences.

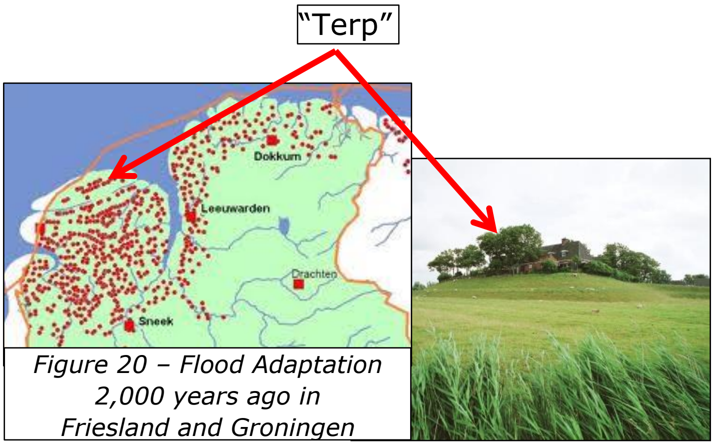


Figure 20 – Flood Adaptation 2,000 years ago in Friesland and Groningen

The reality is different: floods will always re-occur, defences would have to be built higher and higher, creating a false sense of security and any failure of a major system (e.g. Dike Ring 14, protecting the Province of South Holland) would result in disastrous losses, massive loss of GDP and possibly a national bankruptcy. Society changed and demanded a voice. A paradigm shift took place in the way The Netherlands was going to protect itself against floods in the future by accepting the force of nature, giving more room to river to flow, implement flood-proof spatial planning, involve all parties with a stake in water and work with a planning cycle embedded in a long term vision. Sustainable solutions not only require the cooperation of the national government but also the provincial and local government ***and*** the public. This is what is - in essence - water governance.

7.2 Water Governance

Often, a water crisis is also a ***governance crisis***. The *techniques* for providing safe drinking water, water management and flood control are generally available but the real bottlenecks often are related to governance challenges such as institutional fragmentation, lack of systematic planning and solid financial systems. So, not only technical expertise ("hardware", structural measures) is needed but also knowledge on the organisation of water management and the way it is embedded in political, legal, social and financial arrangements ("software", no-structural measures).

Water Governance is an important overarching theme for water security, water safety, water resource development and water supply and sanitation. It is focussing on the institutional, legal, administrative, financial and economic capacities of all stakeholders including the governmental ones, and on communication between and participation of all stakeholders, taking into consideration the social necessities of the society at hand (be it on national, regional or local level). Effective water governance will establish the appropriate combination of these capacities to bring about water availability and water services which is satisfying to all stakeholders at reasonable costs.

In 2011 the Water Governance Centre produced a brief concept note proposing five key building blocks for sound water governance:

- a powerful administrative organization of water management;
- a legally embedded system of water law;
- an adequate financing system and economic analyses of water measures;
- a systematic (planning) approach;
- the participation of stakeholders.

Good water governance, according to the Water Governance Centre, comprises three layers:

- Content layer (policy, knowledge, experience and skills)
- Institutional layer (organisation, legislation, financing)
- Relational layer (culture, ethics, cooperation, communication and participation

The OECD water governance framework describes seven "gaps" which may be an indication to what degree governance is established in society enabling integrated solutions. They include:

- *Policy gap*: overlapping unclear allocation of roles and responsibilities, sectoral fragmentation of water-related tasks across ministries and agencies
- *Administrative gap*: geographical "mismatch" between hydrological and administrative boundaries, this can be at the origin of resource and supply gaps
- *Information gap*: asymmetries of information (quantity, quality, type) between central and sub-national governments, between different stakeholders involved in water policy, either voluntary or not;
- *Capacity gap*: lack of technical staff, time, knowledge and infrastructure, insufficient scientific, technical, infrastructural capacity of local actors to design and implement water policies as well as relevant strategies;
- *Funding gap*: unstable or insufficient revenues undermining effective implementation of water responsibilities at sub-national level, cross-sectoral policies, and investments requested;
- *Objective gap*: intense competition between different ministries, different rationales creating obstacles for adopting convergent targets, especially in case of motivational gap (referring to the problems reducing the political will to engage substantially in organising the water sector);
- *Accountability gap*; lack of citizen concern about water policy and low involvement of water users' associations, difficulty ensuring the transparency of practices across the different constituencies, mainly due to insufficient users' commitment, lack of concern, awareness and participation.

It is important to note that the principles of IWRM (Technical Committee of the Global Water partnership)[7], which is an ecologically-oriented concept, are inclusive of water governance expressed as follows:

[7] Integrated Water Resources Management (IWRM) is "a process which promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." Operationally, IWRM approaches involve applying knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement efficient, equitable and sustainable solutions to water and development problems. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of ecosystems for future generations. Water's many different uses—for agriculture, for healthy ecosystems, for people and livelihoods—demands coordinated action. An IWRM

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment;
2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels;
3. Women play a central role in the provision, management and safeguarding of water.
4. Water has an economic value in all its competing uses, and should therefore be recognised as an economic good.

Table 3 below summarises the different concepts and descriptions of water governance and the relation between the different definitions of the Water Governance Centre, OECD, WGC Academic Panel and WGC.

Table 3 - Reference for Water Governance Level

	THREE LAYER MODEL	**OECD GAP ANALYSIS**	**WGC ACADEMIC PANEL METHOD**	**BUILDING BLOCKS WGC**
CONTENT LAYER	Clear policy	Policy		
	Knowledge and skills	Capacity	Knowledge quality	
	Information	Information		
INSTITUTIONAL LAYER	Organisation	Administration	Institutional quality	Administrative organisation
	Legislation		Juridical quality	Water law planning
	Financing	Funding	Economic quality	Financing system
RELATIONAL LAYER	Culture and ethics	Objectives (motivational)		
	Communication and cooperation	Accountability	Acting and interacting	Stakeholder participation
	Participation			

7.3 Water Governance in The Netherlands

A modest attempt at evaluating the various aspects of governance may be made using "stop lights": red signalling that serious challenges exists regarding filling the gap and that much needs to be done to make progress; orange indicating that progress has been made, but more steps are necessary to improve the status of this aspect; and green saying that there is no appreciable gap for this governance aspect. Table 4 presents the "status" of governance in The Netherlands as perceived by the Team Leader (personal opinion), which serves only as an example. Other opinions are welcome!

This "checklist" may be used as a reference for analysing the status of governance aspects in society as regards water management practices encountered.

---

approach is an open, flexible process, bringing together decision-makers across the various sectors that impact water resources, and bringing all stakeholders to the table to set policy and make sound, balanced decisions in response to specific water challenges faced.

Table 4 – Seven References Regarding Governance

“GAP” list Good Water Governance (OECD)		NL?
Policy gap	Overlapping, unclear allocation of roles and responsibilities; sectoral fragmentation of water-related tasks across ministries/agencies	
Administrative gap	Geographical “mismatch” of hydrological and administrative boundaries that can be at the origin of resource and supply gaps	
Information gap	Asymmetries of information (quantity, quality, type) between central and sub-national government, between stakeholders	
Capacity gap	Lack of technical staff, time, knowledge and infrastructure, insufficient scientific, technical, infrastructural capacity	
Funding gap	Unstable or insufficient revenues undermining effectivevimplementation of water responsibilities at sub-national level;	
Objective gap	Intense competition between different ministries, different rationales creating obstacles for adopting converging targets	
Accountability gap	Lack of citizen concern about water policy and low involvement of water users’ associations, lack of concern awareness and participation	

7.4 Added Value of Dutch Expertise

The added value of Dutch expertise may be summarised as a ***combination of top-level technological innovation & experience in flood control AND extensive knowledge and practical experiences on effective water governance[8] as an important feature for effective IWRM***.

This is the result of the hard lessons learned in The Netherlands concerning water management and flood control and this expertise is internationally relevant. Flood scoping missions need not only analyse the disaster at hand from the technological perspective but also from the governance point of view as to provide implementable and acceptable recommendations.

Cooperation inside **and outside** water management is absolutely essential for integrated solutions in flood management. Main reason is that in many countries water management is allocated in administrative terms to different levels. Secondly, the various components of water management ***share extensive relationships with other policy areas: water and spatial planning, agriculture, food supply energy supply, public health, nature, environment, recreation and fisheries***.

With regard to the Licungo Valley flood, and all other basins in Mozambique, the Dutch expertise has added value as it includes also experience in water governance which is

[8] In 2011 the Water Governance Centre was established in The Netherlands. In the same year a Water Diplomacy Consortium was established

presently insufficiently developed in Mozambique and continues to be an obstacle in the implementation of really integrated sustainable solutions.

Earlier scoping missions such as the mission to the Limpopo Basin, the mission to the Zambezi Valley and the Round Table Conference on Integrated Flood Management held in Maputo in November 2013 have also noted the importance of improving intersectoral coordination.

DNA has taken important steps in recognising the importance of water governance in their Action Plan for the Mitigation and Prevention of Floods. This Plan will need to be worked out further.

ANNEX A – DUTCH RISK REDUCTION

Dutch Risk Reduction Team: reducing the risk of water related disasters

Many countries around the world face severe water threats. Often, these countries are in urgent need of expert advice on how to prevent a disaster or how to recover from a calamity. For instance, when a country has been struck by severe floodings and the first emergency relief workers have gone, the need for advice on how to build a sustainable and safer water future arises. To meet these needs with a swift response, the Dutch government has initiated the Dutch Risk Reduction Team (DRR Team). This team of experts advises governments on how to resolve urgent water issues related to flood risks, water pollution and water supply, to prevent disasters or to rebuild after water related disasters.

With climate change and a fast growing world population, water issues are becoming more urgent. As a country renowned for its' expertise on water and delta management, the Netherlands feels a responsibility to share its' knowledge worldwide. That is just what the DRR team does; sharing expertise with governments to come up with the best possible approach/solutions for tackling urgent water issues. Because of the unique cooperation between government and sector, the best experts can be fielded quickly. The Dutch government offers a specific number of advisory missions each year.

Advice for all water issues

The Netherlands has brought its best water experts together in the Dutch Risk Reduction Team. It consists of high level advisors supported by a broad base of technical experts who can provide top quality and tailor made expertise to governments that are confronted with severe and urgent water challenges. The Dutch are experts in adapting to water in a changing world; from delta management to water technology, from urban planning to governance, public private partnerships and financial engineering.

How does the DRR team work?

Governments that have to deal with an urgent water issue are encouraged to contact the Dutch embassy in their region. The embassy will liaise quickly with the Dutch government. Interventions will only take place after a request from a central government has been received by the Dutch government, and after a recent calamity or to prevent a threatening disaster. The DRR team does not focus on emergency relief, but on sustainable solutions. If the decision to respond to the request is made, relevant Dutch experts will be rapidly fielded to the area that is under pressure. Together with the government and local experts, the situation will be assessed and analysed after which the team will come up with a set of recommendations. For example advice on technical interventions including immediate measures and long term sustainable solutions, advice on governance and advice on financing options. The DRR team enables a foreign government to take action on the basis of sound advice and expertise.

ANNEX B – DRR-TEAM MEMBERS

Jos de Sonneville, Expert IWRM, Team Leader

Fredrik Huthoff, Hydraulic Expert

Henk Karsten, Dike Expert

Álvaro Vaz, local resource person Hydrology and Hydraulics, Maputo

Jan de Moor, local resource person, Agriculture, Quelimane

De DRR-Team was accompanied by Adri Verwey, Flood Specialist, WET Team, World Bank

ANNEX C – TERMS OF REFERENCE

1. Introduction

In January 2015, Mozambique faced the worst floods on the Licungo river since 1971. At least 150 people have died according to the National Disasters Management Institute (INGC). The number of people affected by the floods are around 150,000. Meanwhile 3500 hectares of crops have been lost and another 30,000 ha damaged.

In the beginning of 2015 all countries upstream such as Malawi, Zimbabwe and Zambia have received significantly heavy rains. The combination of upstream countries water run-off and localized rainfall has resulted in an unprecedented rise in the water levels of the Licungu and Zambezi Basin Rivers in Mozambique.

Zambezia is the second most-populous province of Mozambique, located in the central coastal region south-west of Nampula Province and north-east of Sofala Province. It has a population of 3,85 million (census 2007). The provincial capital is Quelimane. Zambézia received abnormally high levels of rainfall - 600 millimetres of rain in 10 days. It caused floods on 12 January that have cut the main north-south road in two and left Nampula, Niassa and Cabo Delgado provinces without electricity for more than a month.

An official request for support from the DRR-Team was sent to the Dutch Government through the National Government of Mozambique, Ministry of Public Works, Housing and Natural Resources, National Directorate of Water (DNA) on the 2nd of February 2015.

DRR-Team is requested to support to the Government of Mozambique through deployment of the DRR-Team. Particular focus will be on Technical Assistance to assist DNA in the elaboration of inundations maps, to evaluate the state of the dikes protecting Nante and Marromeu in the Licungu basin and to assist DNA with the development of a post flood plan for priority and strategic actions to respond to the flood affected area.

These Terms of Reference (ToR) concern a scoping mission to address flood control and a post-flood priority action plan in the province of Zambezia. Further specifications are provided in the following chapters.

2. Mission specifications

a. Scope

The DRR-Team will evaluate, where possible, the state of the dikes protecting Nante and Marromeu in the Licungu Basin, will assist DNA in developing flood inundation maps and assist DNA in the development of a post-flood plan for priority and strategic actions respond to the flood affected areas.

b. Objectives

The Technical Assistance will provide the DNA with advice on a post-flood priority action plan.

The objectives of the scoping mission are:

- Analyse the hydrological events of January 2015 in the Licungo basin, including an overview of the corresponding inundations;
- Assist the Mozambican government in the assessment of the dikes protecting Nante and Marromeu in the Licungu Basin;

- Assist the Government of Mozambique on prioritising flood recovery actions;
- Elaborate on a roadmap for medium- and long-term interventions to reduce the risks and impacts of future floods.

3. Expected results

a. Activities

Desk review (only for team leader):

- Review of available documentation on the disaster situation

During the mission:

- A dike assessment will evaluate the situation of the dikes protecting Nante and Marromeu and provide recommendations on short term measures to be taken. Due to the state of the roads and the short time available for the field visit, it might not be possible to visit all dike failures. In this case a best guess has to suffice, based on experience and local information
- Visits to various stakeholders such as MICOA, NIRI and the INGC
- Active involvement of DNA, ARA Zambeze, ARA Centro-Norte and the Zambezi Development Authority is required;
- The World Bank will be actively involved in the mission;
- There will be close cooperation with the Dutch embassy;
- The mission will elaborate to the authorities in Mozambique on a roadmap for short-medium- and long-term interventions to reduce the risks and impacts of floods;
- Identify possibilities for financing.
- Presentation by the mission of their opinion on whether a follow-up mission should take place and, if positive, what the follow-up activities should include and how these activities will be financed.

Reporting:

- Report writing (as specified in section 3b)
- Debriefing with DRR-Team coordinators.
- Sector meeting after the scoping mission to share the findings of the scoping mission and explore the interest of companies in the Dutch water sector.

b. Output / Deliverables

As a joint effort of the team of experts the mission has to result in the provision of the following reports:

- **Report for the requesting authority:** A report with a description of conducted activities, including well-defined sustainable measures, findings and recommendations for the requesting authorities on how to take measures as a response to the critical situation. This report should include an overview of the persons that have been contacted and activities that have been conducted. In addition, this report should include (general) possibilities for financing;
- **Report for the DDR-Team:** A separate report or addendum to the mission report, that outlines follow-up activities and possible opportunities for the Dutch water sector;

- **Report for EKN/DRR-Team coordinators:** A short evaluation of the mission where the team and EKN can outline what aspects of the mission went well and which aspects could use improvements.

With regards to the reporting, the following standards are maintained:

- The findings and recommendations shall be presented in a reader friendly and professional manner and may include illustrations and photos;
- An electronic version of the final report along with all the relevant annexes;
- A summary of the mission of maximum 2 pages, which can be used for publication on websites of EKN and RVO.nl/drrteam.nl;
- Representative(s) of the expert team should be available to present the findings during a (sector) meeting in the Netherlands.
- All reports and communication will be in the English language, including a management summary in both English and Portuguese.

4. Required expertise

The scoping mission consists of 1 Dutch team leader, and 2 experts from the water sector. The mission will be accompanied where possible by Embassy staff members. A resource person will be added to the team. The required expertise is as follows:

- Team leader and expert in integrated water management;
- Dike expert
- Hydraulic expert
- Local expert on the region of the Licungo Basin

Selection of experts: The team members will be selected based on expertise on integrated and adaptive (climate-change proof) approaches to water related challenges and of water related disciplines relevant to disaster risk reduction; delta technology, flood control, land reclamation, water supply and sanitation and/or financing/governance; and business development, and with relevant experience in the requesting country. Where possible experts already available in the requesting country will be selected for cost saving purposes.

5. Timing

The scoping mission should take place between 11/04 and 21/04 2015. This scoping mission will take 11 days (9 days mission and 2 days travelling).

ANNEX D – REQUEST FOR SUPPORT

INGEKOMEN

2015 -02- 06

REPÚBLICA DE MOÇAMBIQUE
MINISTÉRIO DAS OBRAS PÚBLICAS, HABITAÇÃO E RECURSOS HÍDRICOS
DIRECÇÃO NACIONAL DE ÁGUAS

PARA:
Embaixada do Reino dos Países Baixos
Att: Chefe da Cooperação e Desenvolvimento
Sr. Jan Huesken

Maputo

Nota nº: 11 /502/B3.1/DNA ***02 de Fevereiro de 2015***

Assunto: **Solicitação de Assistência Técnica Holandesa face as Cheias de 2015**

Exmo. Senhor,

Na presente época chuvosa, no mês de Janeiro de 2015, registou-se fortes precipitações e persistentes nas regiões Centro e Norte do País, que contribuíram para o aumento do volume de escoamento nas bacias hidrográficas do Zambeze e Licungo resultando em inundações que causaram perda de 134 vidas humanas na província de Zambézia até a data.

De acordo com dados avançados até ao momento, cerca de 62 mil hectares de campos agrícolas ficaram efectadas e destruição de infraestrutura sociais e económica (pontes, vias de acesso, linha de transmissão de corrente eléctrica) na bacia do Licungo.

Na bacia do Zambeze persiste o cenário de escoamentos altos, sobretudo, no Baixo Zambeze, como consequência das chuvas registadas localmente e contribuição dos escoamentos dos Países a montante, condicionando a transitabilidade das vias de acesso, provocando inundações em campos agrícolas nas zonas baixas e ribeirinhas.

Face a esta situação, o Governo de Moçambique decretou o Alerta Vermelho institucional para as regiões Centro e Norte do País.

No concernente a ajuda de emergência, o Governo Moçambicano solicitou oficialmente assistência às Nações Unidas no dia 19 de Janeiro do corrente ano. O pedido foi acolhido positivamente e por sua vez, o apoio foi encaminhado ao Centro Nacional Operativo de Emergência (CENOE).

Tendo em consideração os longos laços de cooperação no Sector de Águas entre o Governo de Moçambique e de Reino dos Países Baixos, vimos por este meio

Avenida 25 de Setembro n.º 942 11º.Andar Tel. 21 322191/2 Fax n.º 21 305240 www.dnaguas.gov.mz

solicitar uma Assistência Técnica urgente e de curta duração em matéria de gestão de desastres naturais provocados pela água.

É de salientar que a Assistência Técnica, dentre vários assunto, deverá apoiar a DNA na elaboração do mapa de zonas de inundações, avaliação do estado dos diques de defesa de Nante e Marromeu, e na elaboração de um plano de acções prioritárias e estratégicas pós-cheias 2014/2015.

Melhores cumprimentos.

O Director Nacional Adjunto

REPÚBLICA DE MOÇAMBIQUE
DIRECÇÃO NACIONAL DE ÁGUAS
DEPARTAMENTO DE RECURSOS HÍDRICOS

Hélio M. J. Banze
(Técnico Superior O. P. N1)

Avenida 25 de Setembro n.º 942 11º.Andar Tel. 21 322191/2 Fax n.º 21 305240 www.dnaguas.gov.mz

ANNEX E– BRIEF MINUTES OF MEETINGS

IN MAPUTO

Hotel:
Informal meeting with Álvaro Vaz, Consultec. Mr Vaz participated in the scoping mission to the Zambezi and Licungo Basin in april 2013. The upcoming mission and his recommendations for our discussion were discussed. Until now no hydrological study of the Licungo Basin has been executed. In relation to the recent floods, it is necessary to collect information on the state of the present hydrological network, the communication between ARA Centro-Norte and INAM, the existence of the type of flood models available for the Licungo Basin and if the flood model available useful during the flood, the personnel available in ARA Centro-Norte and their professional level, whether a study was made on the discharge capacity at Mocuba Bridge, and if after the 2013 floods return periods were established and if the upcoming Licungo Basin Study (under tender) includes flood aspects.

Embassy:
A brief introduction of Multi-Annual Strategic Plan 2014 – 2017 signed with DNA including the changes that have taken place since the elections (new minister, Carlos Boneto Martinho and vice-minister, João Osvaldo Moisés Machatine), the ongoing organisational changes in DNA. The issues of water resoures are now more recognised in the Ministry which is reflected in the new name. A request was made by the Embassy to pay attention to state of the Munda-Munda project, an important irrigation development in the Licungo basin near Nante. Munda-Munda is an ORIO project led by Jan de Moor, local resource person. The mis seen as a new starting point in the cooperation with DNA.

DNA:
Briefing by DNA, welcome by the Director, Suzana Saranga and Deputy Director Hélio Banze. Mrs Rute Nhamucho gave a presentation on the Vision of DNA with regard to flood management and the actions to reach the stated goals. An overview was given on the progress made on the recommendations by the two scoping missions to the Limpopo Basin and Zambezi (and Licungo) Basins executed in 2013 and the situation as per April 2015, followed by a discussion on the itinerary of the field visit and logistics. JICA has worked in the Licugo and are planning to make a flood model of thre Licungo Basin. Korea is interested (offering?) to elaborate a National Water Resources Plan. DNA is looking very much forward to the Strategic Technical Assistance project to Suport DNA during the coming two years in their mission. DNA hopes that the TA can give direction to the medium and long term measures to be taken. Further planned actions include the preparation of a National Programme reducing the vulnerability against floods, the creation of a unit in DNA responsible for the implementation of the actions, the improvement of the inter-institutional (inter sectorial) cooperation in the implementation of actions for prevention and mitigation of natural disasters (floods, droughts) and the efforts to increase the finding necessary mitigation plans and improvement of the networks for monitoring and early warning.

MITADER:
Meeting with Mrs Helena Ribeiro. Discussion on the PEOT (Plano Especial de Ordenamento Territorial) seen as an important development. In the first phase plan will cover the districts of the Zambezi River. In de second phase the plan will be extended to the other basins in Zambezi Province. (PEOT is a multi-sector development plan where environmental and social aspects are cross-cutting elements). IN the PEOT activities

there is cooperation with the ARA Zambezi. IUCN and INGC are looking for a financier to execute a study on biodiversity in the region. Important is to know that LIDAR is flown in the Limpopo Basin and the Zambezi Basin.

INIR (National Irrigation Institute, established in 2012)
Director Paiva Munguambe. He indicated that JICA was also requested to visit the Licungo Basin and had made a video. He indicated also the issue of dike and road maintenance, lack of data on return periods. In the Licungo three irrigation developments are under way: Munda-Munda with 3,000 ha, Intabo with 5,000 ha and Morire with 108 ha. INIR has a strategic development plan with 6 development corridors: Maputo – potatoes, vegetables, Limpopo – rice, horticulture, livestock, Beira corridor – (?), Zambezi and Licungo Valley – rice, Nacala corridor and Pemba, Lichinga. For the PEOT a consultant was hired to determine the agricultural potential (done for all the corridors, finished September 2014), and the irrigation extensions (Consultec and Proscel). GIZ executed a climate proofing exercise (Prof Rui Brito). Any intervention undertaken by INIR is discussed with DNA. He gave examples of cooperation on water allocation for irrigation. Maintenance of dikes and responsibility was discussed and the acceleration of the development of water use associations (< 1 ha no payment for water).

INGC:
Director João Ribeiro. Explains INGC whose principal task it is to coordinate relief efforts. He indicates that if they have a 3-day advance warning, they are able to extract the people. He indicates that they were only warned when the problem already started. There is not enough information in the different localities. There is a need for spatial planning. At the moment about 50% f the population lives the flood plains. His suggestion is to detach people form DNA during times of floods. Compared with before, the population is better prepared. This time the flood in the Shire River added to the problem. INGC has formed Risk Committees in the country. Nation-wide 4,000 are necessary. Until now 1,000 have been established. The incomplete coverage of Risk Committees in the Licungo Basin could have contributed to the problems experienced. He indicates the great need to make multi-disaster risk maps. He pleads for more cooperation between the different organisations involved in Flood and disaster management.

MITADER:
Reinaldo, Director de Planificção e Estudos. He refers also to the PEOT and the progress in four (?) provinces, mentioning principal pints of attention: floods, natural disasters (droughts, sedimentation), saline intrusion (coastal areas) and population growth (2-3%). He mentions that water should be the focal point and first to be considered in relation to sectorial development. The goals of the PEOT are to make a robust physical planning of the region and that way prevent conflicts such as those between tourism, mining, nature reserves, urbanisation. Discussion on making nature corridors, establish forest reserves, and making Tete a urban conglomerate. DNA has an important role in the planning. The horizon of the study is 30 years to be approved by the Ministerial Committee. The pan should be finished by September 2015. The Licungo basin is not part of this plan. Indicates that in the Zambezi 40% of population lives in the coastal zone and that there is no public decision making process and that it is necessary to review the laws pertaining to spatial planning. As priorities he mentions the issues of resettlement, the introduction of adaptation measures, sedimentation (blocking drinking water intakes along the river) and saline intrusion.

IN THE FIELD (QUELIMANE, MOCUBA, MAGANJA DA COSTA, NANTE)

Courtesy visit and briefing in Mocuba

During the field visit the team split in two sub-teams. One team made a courtesy visit to the Provincial Directorate of Agriculture Gaza, the Provincial Directorate of Public Works and Housing Gaza and attended by the persons listed below.

Name	Institution	Telephone	Email
Ilídio Bande	DPASA - Director	824789180 843025326	bande.ilidio@gmail.com
Adri Verwey	BM	847757844	adri.verwey@floodconsult.com.sg
Amélio Miguel Gasppar	DPOPHZ/DAS	823921740	ameliaelluamiguel@yohoo.coom.br
Américo J. Chivale	DPOPHZ -Director	823853140	ajeremia@gmail.com
Braz Anselmo	DPA	822707482	anselmobraz@yahoo.com
Fredrik Huthoff	Gov. Holandês		Fhuthoff@hkv.nl
Inocênco A. Escova	ARA CN	82/843051832	escova@yahoo. Com.br
Jos de Sonneville	Gov Holandês	821099411	josdesonneville@waterwys.nl
Madeus Luciano	INGC	823808830	madleeciano@hotmail.com
Pascoal da C. Linda	DPASA	825446780	pascoallinda@yohoo.com.br
Rute Nhamucho	DNA	824093670	rnhamucho@dnaaguas.gov.moz

The Team explained the purpose of the mission which, in addition to the previous visits of WB and JICA, is to make a more detailed analysis of the state of the dikes near Nante and Marromeu, analyse the flood and provide short, medium and long term recommendations for flood control. The WB also joined the DRR-Team to examine the opportunities of financing the recommendations within the international financing arena for Mozambique. The team stressed the prominent role water has, especially in the flood plains, with regard to spatial planning. In the lower valleys and the flood plains water is not only a sectorial resource but also a dominant factor in multi-sector development and spatial planning.

Debriefing in Quelimane

Name	Institution	Telephone	Email
Sergio A. Baltasar	DPOPHR/DAS	820535391	?
Adri Verwey	WB	847757844	adri.verwey@floodconsult.com.sg
Albano Leite	INIR-MASA	825095340	albanoleite@yahoo.com
Américo J Chuvale	DPOPHR	823853140	?
André Zibia	DNA	825615729	?
António Jaspion Cheia	PROIRRI/DPASAZ	845180371	tchecotcheco@yahoo.com
Braz E. Anselmo	DPA	822707482	anselmobraz@yahoo.com
Fredrik Huthoff	Gov. Holandês		Fhuthoff@hkv.nl
Henk Karsten	Gov. Holandês	825460929	henkkarsten@yahoo.com
Inocência Escova	ARA CN	823051833	escoraiya@yahoo.com
Jabula Arlindo Zibía	DPASA	846426765	jazibia@yahoo.com
Jan de Moor	ZAMIRRI Lda	824028490	jandemoor1950@gmail.com
Jos de Sonneville	Gov. Holandês	821099411	josdesonneville@waterwys.nl
Natalino F. Moisés	SDAE, Mag Costa	824421570	natalinofernando@?
Sérgio Auela	ARA CN	824225610	bethosk@yahoo.com

At the end of the field visit a debriefing meeting was held at the provincial HQ of DPOPHRH to inform the provincial and district representatives on the results of the mission. The meeting was attended by the persons indicated above.

The team presented an analysis of the flood of 2015, gave a summary on the state of the dikes and the cost for rehabilitation and presented short and longer term recommendations. The meeting resulted in a lively discussion on timing of activities. Important is to have all dikes repaired before the next flood season, which gives urgency to the financing this activity.

ANNEX F – MISSION PROGRAMME

From		To	Duration	Event	Venue
Saturday, 11 April					
07.00				Arrival Henk Karsten	
Sunday, April 12, 2015					
08.30	-	12.30		Reading mission info, Henk Karsten	
09.40				Arrival Jos de Sonneville	
10.40				Arrival Fredrik Huthoff	
12.30	-	17.30		Meeting Jos de Sonneville, Fredrik Huthoff, Alvaro Vaz (local resource person)	Terminus
Monday, April 13, 2015					
08.30	-	10.00		Briefing at Embassy, Ambassador Frédérique de Man, Farida Saifodine, Célia Jordão	RNE
10.30	-	12.00		Briefing by DNA on mission, Director Suzana Saranga, Hélio Banze, Rhute Nhamucho, André Zibia, Egídio Govate, Jossefa, Agostinho Vilankulos.	DNA
14.00	-	16.00		Meeting MICOA, Mrs Helena Ribeiro, DNA, Egídio Govate, INGC, Xavier Chavane	RNE
14.30		17.30		Working session for preparation of field visit (H. Karsten, Rute Nhamucho, André	DNA
18.00	-	20.30		Working session for preparation of field visit (Jos de Sonneville, Fredrik Huthoff, H. Karsten)	Terminus
Tuesday, April 14, 2015					
08.00	-	10.30		Mission work, planning of field visit, preparation, Henk karsten	
09.00		10.00		Meeting INIR, Mr. Paiva Munguambe	RNE
10.30	-	12.00		Meeting INGC, Director João Ribeiro	INGC
10.30	-	11.30		Meeting with DNA on site visit program, Rute Nhamucho, Henk Karsten.	DNA
13.00	-	14.30		Meeting MICOA, Mr Reinaldo, Direcção de Planificação e Estudos	MICOA
17.10				Arrival Adri Verwey	Beira
18.00	-	22.00		Travelling by plane to Quelimane, welcomed by Escova, Jan de Moor and Braz Anselmo (Rute Nhamucho, Albano Leite, André Zibia, Jos de Sonneville, Fredrik Huthoff, Henk Karsten)	
22.00	-	23.00		Travelling by two cars to Zalala (Escova, Sergio, Rute Nhamucho, André Zibia, Jos de Sonneville, Fredrik Huthoff, Henk Karsten)	Zalala Quelimane
Wednesday, April 15, 2015					
05.00	-	11.30	6.30	Travel by car from Zalala to Maganja da Costa (Team split in Technical group and Study group). Adri Verwey joint the team in Quelimane.	
9.00	-	10.30	1.30	Meeting MOPHRH, Américo Chivale, DPA, Director Ilidio Bande, See also participant list (Study group).	Mocuba
11.30	-	12.30	1.00	Courtesy visit to Agriculture and Administrador and lunch (technical group).	
11.00	-	11.30	0.30	Visit to ARA Centro--Norte Office, Mr Escova (stydu group).	Mocuba
11.30	-	12.30	1.00	Courtesy visit Chefe de Poste (study group).	Nante
12.30	-	13.30	1.00	Travel by car from Maganja da Costa to Nante and Coffie at ORAM house (Technical group).	
13.30	-	17.30	4.00	Site visit to Naminane breach and broken bridge. (Complete team, 2 KM and back)	
17.30	-	18.30	1.00	Travel by car from Nante to Maganja da Costa, lodging arrangements.	
Thursday, April 16, 2015					
05.30	-	06.30	1.00	Travel by car from Maganja da Costa to Nante.	
06.30		08.00	1.30	Cofee and arrangement of bycicles	
08.00	-	12.45	4.45	Site visit: Nante - Munda Munda - Muguloma - Morla - Intabo (André Zibia, Jan de Moor, Braz Anselmo, Albano Leite, Xavier Cafferman, Thirza Mandos, Henk Karsten, 10 KM and back)	
13.00	-	15.00	2.00	Retour Intabo - Nante.	
15.00	-	22.15	7.15	Travel by car from Nante - Maganja da Costa, Mocuba - Quelimane (Heavy rainfall between Nante and Maganja da Costa	
23.15	-	00.00	0.45	Travel by car from Quelimane to Zalala.	
Friday, April 17, 2015					
7.15	-	8.15	1.00	Travel by car from Zalala to Quelimane airport.	
8.00		15.00	7.00	Study Team prepare conclusions and presentation for debriefing Provincial	
9.00	-	10.30	1.30	Travelling by Helicopter from Quelimane - Intabo - Nante - Ilima - Quelimane. (Bras Anselmo, André Zibia, Claudio Chicovela-AVDZ, Abdul-Pilot, Henk Karsten)	
10.20	-	10.45	0.25	Fueling of Helicopter in Quelimane	

From		To	Duration	Event	Venue
10.45	-	12.10	1.25	Travelling by Helicopter from Quelimane - Luabo - Mopeia - Marromeu. (Braz Anselmo, André Zibia, Claudio Chicovela-AVDZ, Abdul-Pilot, Henk Karsten)	
12.10	-	13.35	1.25	Courtesy visit to Administrador and other authorities of Morrameu. The Helicopter went for fueling to Caia.	Administrador
13.35	-	14.00	0.25	Flight above dykes of Marromeu town and SENA. (Patrice Mhuru-SENA, Alberto Pechisso-ARA Zambeze, Magaja Dete Assane-Dir. Infraestruturas, José Antonio Chicote, Abdul-Pilot, Henk Karsten)	
14.00	-	14.50	1.50	Travelling by Helicopter from Marromeu to Quelimane. (Bras Anselmo, André Zibia, Claudio Chicovela, Abdul-Pilot, Henk Karsten)	
15.00	-	16.00	1.00	Both Teams Travelling by car from Quelimane to Zalala	Quelimane
16.00	-	24.00		Report writing, first version of List of breaches with cost estimate, powerpoint preparation debriefing.	
Saturday, April 18, 2015					
08.30	-	9.30	1.00	Travelling by car from Zalala to Quelimane	
10.30	-	12.30	2.00	Debriefing at Public Works, see also the participants list.	Public Works
12.30	-	18.00	5.30	Lunch and exchange of info at office Jan de Moor	
19.00	-	24.00	5.00	Travelling by plane from Quelimane - Nampula - Maputo	
Sunday, April 19, 2015					
09.00	-	11.00	2.00	Work on report and debriefing presentation, handing over information from Henk Karsten who will leave next day early	
11.00	-	13.00	2.00	Informal meeting of team with r Álvaro Vaz to discuss results	
14.00	-	16.00	2.00	Discussion with Adri Verwey, Worldbank	
16.30		19.00	2.30	Preparation of presentation with team members. (Jos de Sonneville, Fredrik Huthoff, Henk Karsten)	Terminus
22.00	-	01.00	3.00	Final preparation debriefing and results	
Monday, April 20, 2015					
05.00				Departure Henk Karsten	
8.00	-	9.00		Debriefing Embassy staff;	Embassy
9.00	-	10.30		Debriefing delegations INGC, INIR, MICOA, DNA, MPD	Embassy
10.30	-	11.30		Meeting with Worldbank: Mr Roberto White and Mr Adri Verwey	Embassy
13.00	-	14.30		Debriefing DNA	DNA
14.30				Departure Jos de Sonneville (flight at 17.30)	
Tuesday, April 21, 2015					
				Departure Adri Verwey	
Wednesday, April 22 to Sunday, May 3, 2015					
				Departure Fredrik Huthoff	

ANNEX G - SUMMARY OF DNA BULLETINS 9-16 JAN 2015

9-1-2015	**Gúruè:** **P: 26.9mm , WL: 4.18m** **(WL alert level 3.5m)** **Mocuba:** **P: 13.1mm, WL: 5.32m** **(WL alert level 6m)**	**The Licungo basin continues to record increase in the flow volume as a result of the rains. The hydrometric levels showed an increase but remain below alert level,** ***It was not mentioned that water level at Gúruè was above alert level.***	**Hydrometric oscillatory levels with a tendency to stabilize and to remain below alert level.**	**The DNA recommends taking precautionary measures and maintain the equipment and goods in safe areas due to the high volume flows.**
10-1-2015	Gúruè: P: 12.6mm , WL: 2.12m (WL alert level 3.5m) Mocuba: P: 31.2mm, WL: 6.55m (WL alert level 6m)	The basin of the Licungo in Mocuba met and exceeded the water level alert level.	In the Licungo basin at Mocuba, a stabilization of hydrometric levels in the next 24 hours is expected, remaining above the alert level. In the next two days a substantial increase of hydrometric levels is anticipated at Mocuba station, reaching levels above 8 meters.	DNA recommends to observe precautionary measures and draws special attention to the possibility of flash floods and erosion that can lead to the destruction of infrastructure and property in urban areas of MOCUBA, NAMPULA, NACALA, QUELIMANE and PEMBA by the accumulation of rainwater.
11-1-2015	Gúruè: P: 22.7mm , WL: 3.05m	The basin of the Licungo in Mocuba shows gradual decline of hydrometric levels, with the Mocuba station now	In the basin of Licungo in Mocuba, hydrometric levels are expected to vary significantly with a tendency to rise and possibly again	DNA recommends to observe precautionary measures and draws special attention to the possibility of flash floods and erosion that can lead to

	(WL alert level 3.5m) Mocuba: P: 12.0mm, WL: 5.73m (WL alert level 6m)	below Alert level.	reach the alert level.	the destruction of infrastructure and property in urban areas of MOCUBA, NAMPULA, NACALA, QUELIMANE and PEMBA by the accumulation of rainwater
12-1-2015	Gúruè: P: 224.0mm , WL: 5.25m (WL alert level 3.5m) Mocuba: P: 102.2mm, WL: scale submerged (>12m) (WL alert level 6m)	The catchment area of Licungo in Mocuba records high volume flows, resulting from heavy rains that are registered in Zambezia province, especially in the highlands of Gúruè, Namarroi and Tacuane. The bridge over the river in Licungo EN1 linking the cities of Mocuba and the North Country is interrupted.	In the Central region, a continuation of rising hydrometric levels is expected in the basin of Licungo at Mocuba	DNA appeals populations living in areas prone to flooding along the Licungo basin to back off immediately from risk areas.
13-1-2015	Gúruè: P: No data, WL: scale submerged (WL alert level 3.5m) Mocuba: P: 43.3mm, WL: scale submerged (>12m) (WL alert level 6m)	In the country's central region, due to strong and persistent rain, the basin of Licungo remains on high alert.	Due to the prevalence of rain a continuation of high volume flows in the LIcungo basin is expected. The Lower Licungo will continue to record rising water levels.	DNA appeals populations living in areas prone to flooding along the Licungo basin to back off immediately from risk areas.

14-1-2015	Gúruè: P: No data , WL: scale submerged (WL alert level 3.5m) Mocuba: P: 87.9mm, WL: scale submerged (>12m) (WL alert level 6m)	In the country's central region, the watershed of Licungo remains on high alert and continues interrupted the road link between the center and the north of the country in Mocuba City at EN1	The prevailing hydrological situation and weather forecasts in the Central region indicate that the basin of Licungo will continue to register high volume flow, especially in the Lower Licungo, and the tendency will be to stabilize water levels.	DNA appeals populations living in areas prone to flooding along the Licungo basin to back off immediately from risk areas.
16-1-2015	Gúruè: P: 5.8mm , WL: 3.8m (WL alert level 3.5m) Mocuba: P: 4.2mm, WL: 7.9m (WL alert level 6m)	In the basin of Licungo, despite the reduction in flow volume, the prevailing flooding in the lower continues to interrupt road traffic.	The basin of Licungo shows gradual reduction of the flow volume, given the slowdown of rainfall in the region. However, the water level in Mocuba station can remain above the alert level.	DNA appeals populations living in areas prone to flooding along the Licungo basin to back off immediately from risk areas

ANNEX H – PHOTOS FIELD VISIT TO INSPECT DIKES

The breach number, date and location of the breaches were derived from the Cost Estimate for easy reference. A detailed description is given for each photograph.					
Distances KM	Quelimane - Mocuba 150, Mocuba - Maganja da Costa 110, Maganja da Costs - Nante 29, Nante - Naminane 2, Nante - Intabo 10				
#	DATE	LOCATION	#	DATE	LOCATION
	15/4	Naminane Dike			

View from the start of the semi-circular dike. This part of the dike is lower and has been overtopped by 1.80m of water. The sediment right side of dike was deposited by the floods.

1+2	15/4	Naminane Bridge and Breach

The concrete bridge was broken and inhabitants cross the breach by canoe

1+2	15/4	Naminane Bridge and Breach

The grasses and debris in the palmtree show the level of the flood. The brown soil was freshly deposited by the 2015 flood.

#	DATE	LOCATION	#	DATE	LOCATION
	15/4	Dique Naminane			Nante end of Dike
					
The flood waters have flattened the grasses but the dike has remained in tact. The local farmers have burned a part of the grass so as to reopen the access.			Mr. Sergio with the arm on the water level gauge. This gauge was overflown by more than a man-height of water.		
1	16/4	Dique Valintim	2	16/4	Dique Valintim
					
Typical breach form in the area. The erosion shows a layered patron, possible a result of compaction of too thick layers.			The bycicle party is visible at the end of the breach		
	16/4	Dique Valintin	14	16-4	Valintin Dike, semi circular dike
					
Typical breaches. The big breach cioncides with a passage. This is observed in several cases.			These breaches form an exception as most dikes with soft slopes remained in tact. The loop was build to contour a large breach, too deep to fill.		

#	DATE	LOCATION	#	DATE	LOCATION
	16/4	Dique Munda Munda	Same breach from the other side.		
					
Small breach in the access road to Munda Munda. Jan de Moor (L) and Xavie Cafferman.			Same breach from the other side.		
21	16/4	Dique Munda Munda	26	16-4	Munda Munda road crossing
					
Partly destroyed intake station with pump (blue).			Where Xavier is standing started a dike to the far right. The intake station is partly destroyed.		
26	16/4	Dique Valintin	26	16-4	Breach at road crossing Munda Munc
					
Albano Leite testing the temporary bridge.			Road-intake canal crossing from the air.		

# DATE LOCATION	# DATE LOCATION
Munda Munda	

The intake station of Munda Munda is situated in the center of this aireal view. The road crosses the picture from far right to far left in the middle of the photo. The intake canal and the irrigation scheme are visible in the back ground. The intake section of the river is shown in the left-bottom corner. The continuation to the right (down stream) of the dike stretches from the station to the the right-bottom corner of the picture and is severely damaged. This dike continues to Eribacila weir complex.

31-32 16-4 Eribacila weir complex.

The weir is heavely damaged. In the back ground, left, the intake canal and the irrigation scheme are visible.

#	DATE LOCATION	#	DATE LOCATION
Road between Munda Munda and Muguloma			

The top of the road is damaged by over flowing water over a length of 5000 m (Estimated) and will need repair so as to allow for passage of cars.

The house of the Fumo (Local authority)

shows the latest water line at the down side of the window.

#	DATE	LOCATION
60	16-4	Intabo intake station

The intake station and the canal are visible at the edge of the trees. The river that diverts to the left was created by the flood and inundated vast areas inland. The dike is broken over some 150 meters. The agricultural experts raised the question whether the dike should be re-installed or that an other solution is to be designed.

53-57	16-04	River berm of Muguloma

Before arriving at Intabo the road borders the river very closely. In many places the berm has been eroded by the water, probably not only by the last flood of 2015. The houses of the inhabitants of the zone lay behind the road. In order to safeguard the road action should be taken to protect the berm. The installation of Gabions may give a mid-term solution. In case the road is to serve more traffic in future more permanent works may be necessary.

#	DATE	LOCATION	#	DATE	LOCATION
59	16/4	Intabo intake station			Waterlivel during the 2015 flood.

The water of the flood of 2015 has over flown the ground level of the station by about 0,60 m. The soil in front of the building was reportedly removed by the floods. Amazingly rapidly the plants have grown in that washed-out area.

#	DATE	LOCATION
	17-4	Town of Luabo

The town of Luabo seems abandoned. Fields in the surrounding do not seem to be used. No major breaches were seen in the dikes during the flight. Detailed surveys on the ground may shown hidden damages, also originating from earlier floods.

#	DATE	LOCATION
	17-4	Town of Mopeia

The dikes visible on this picture seem to be intact and heavely over grown by greens. On several parts crops are grown on the sides of the dike. This practice should be forbiddenas it degrades the quality and the level of the dikes..

	17-4	Dikes in the vicinity of Marromeu

The dikes in the surroundings of Marromeu do not shown major breaches. In general the dikes are overgrown with greens, mainly elephant grass. On several places agriculture is being practiced. This should be forbidden as it degrades the quality and the level of the dikes.

#	DATE	LOCATION
17/4	17-4	Surrounding of Marromeu

The dikes visible in this picture do not show major flood damage and seem to be over grown with grasses for several years.

ANNEX I – CONSEQUENCES 2015 FLOODS MUNDA MUNDA PROJECT

Introduction

As part of the DRR mission to the Licungo basin, and at the request of the Royal Netherlands Embassy, particular attention was given to ongoing and future plans in the Munda-Munda project. This project is of immediate importance to the well-being and prosperity of the region as it provides the largest single agricultural area in the Licungo basin. During the 2015 flood, the hydraulic infrastructure of the Munda Munda irrigation area was severely destroyed. Considering the much higher than expected flood levels, a rethink is required on the proposed design of the new gravity feed irrigation infrastructure, and the optimum, economically feasible, dike design.

The dikes near Nante serve partly as a road and are primarily for the protection of the present Munda Munda irrigation area and the local population, while providing transport connection between villages (Nante itself lies above the latest flood level). Currently, the Licungo floodplain downstream of Mocuba is primarily used for subsistence agricultural production but the soil is very fertile and has potential for more intensive agricultural production. There is also a good market for an increased production of rice, as Mozambique is importing rice to supplement it needs.

Flood management and agriculture are very closely linked. In this chapter the further development of the Munda Munda project will be introduced, the objective of which is to modify the hydrological environment to enable gravity fed irrigation. After that the influence of the recent floods on the implementation of mainly the river works is discussed, including a time schedule wherein river basin water management and flood strategies will be related to the implementation plan of the Munda Munda project.

Description of the Munda Munda project

The Munda Munda irrigation project is situated on the left bank of the Lower Licungo River. An area of 3,000 ha will be irrigated by gravity using the existing lake system. The beneficiaries are 5,500 small holders (60% women) which have their land in the project area. Actual land occupation is dense and used for subsistence agriculture. In 2009 a concept note of the project was presented to the Agentschap.nl (now RVO.nl) and a project proposal was approved in 2011. During 2012-2013 the development phase of the project was executed. Eight studies were executed (mapping & topography, land & water rights , hydrology, extension & postharvest, irrigation & drainage pre-design, rural economy, environment and river works) and on the basis of these studies a implementation and procurement plan was elaborated with a activity based budget reflecting the engineer’s price of the works and services. In 2013 the implementation and O&M phases with a budget of 17.9 M Euro were approved. The budget will be supported by the Mozambican Government (45%), ORIO (45%) and the beneficiaries (10%) through their labour input. The implementation phase will be executed in six years while the O&M phase will take still two years more; (total 2015-2023).

Modifying the hydrological system enabling gravity fed irrigation

In the figure 21 the main new hydraulic infrastructure is schematically designed. In point 1 a free intake on the Licungo river will be constructed to drain water from the main stream into the Namagone river. The Namagone river is passing several swamps and joins the main river downstream. Half way in the river near the village Ilima (2) a sluice complex will be constructed to drain 10 m3/s into a link channel which will transport the water to the Tandamela lake (3). This link channel will have a length of approximately 5 km and will have three drop structures to control the velocity of the stream flow in the channel. The Tandamela lake will be used as a reservoir to raise the water level by two meters. The natural outflow of the lake through the Cune river will be blocked. Instead of this natural outflow a second sluice complex will be constructed near Nante (4) while a part of the dike, linking the dunes of Nante and Moneia, will be reconstructed with a final crest level enabling storage of the irrigation water in the Tandamela lake. The sluice complex will regulate the flow downstream the lake into the Cune River. Through the natural system of the Cune River the water will be transported to the Munda Munda main inlet gates (5). The flow of the Cune river downstream of the Munda Munda inlet is controlled by the retention dam Eribacila. The Eribacila dam was constructed in the

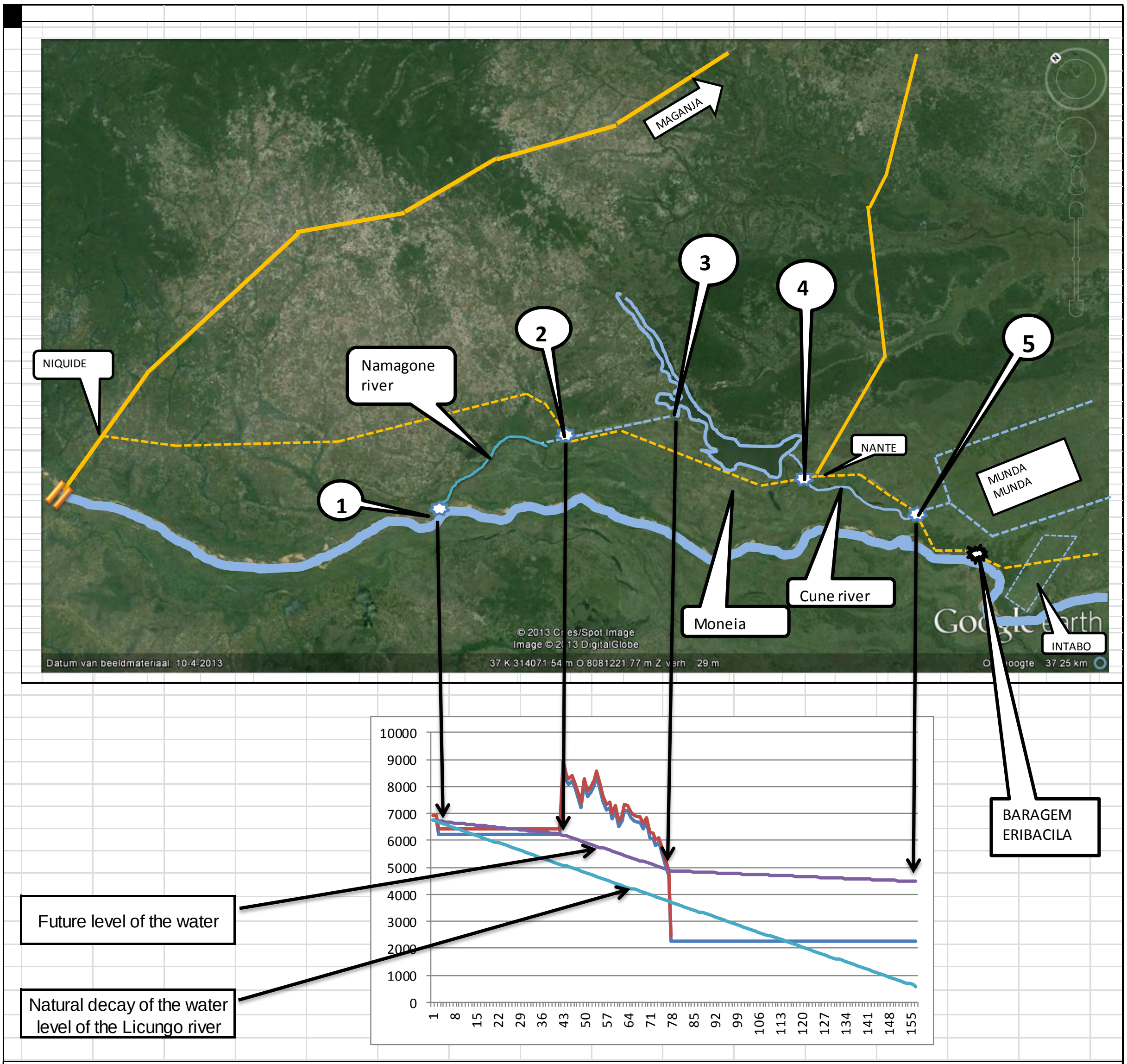


Figure 21 Basic design of the new hydraulic infrastructure to enable irrigation by gravity

sixties of the last century and rehabilitated in 2005. The lower part of figure 21, below the google map, indicates the natural inclination of the Licungo River and the future water levels in the Namagone River, link channel, Tandamela Lake and the Cune River. Through this infrastructure gravity fed irrigation will be possible avoiding expensive pumping costs.

The Munda Munda project after the January 2015 floods

As in the other parts of this report was stated; the recent floods in the river basin of the Licungo river were exceptional. That is why certain parts of the Munda Munda irrigation project must be adapted to this new situation; specially the dikes and river works. In this paragraph we will discuss some critical issues and places where adaption is needed. First of all the situation at free intake at the bifurcation of the Namagone River. It was clear, already before the January 2015 floods that this structure must be built in such a way that it can be inundated without being destroyed during the passage of the floods. The second critical point is the situation near Ilima. Figure 22 shows the future sluice complex with the link channel in a *google earth* map.

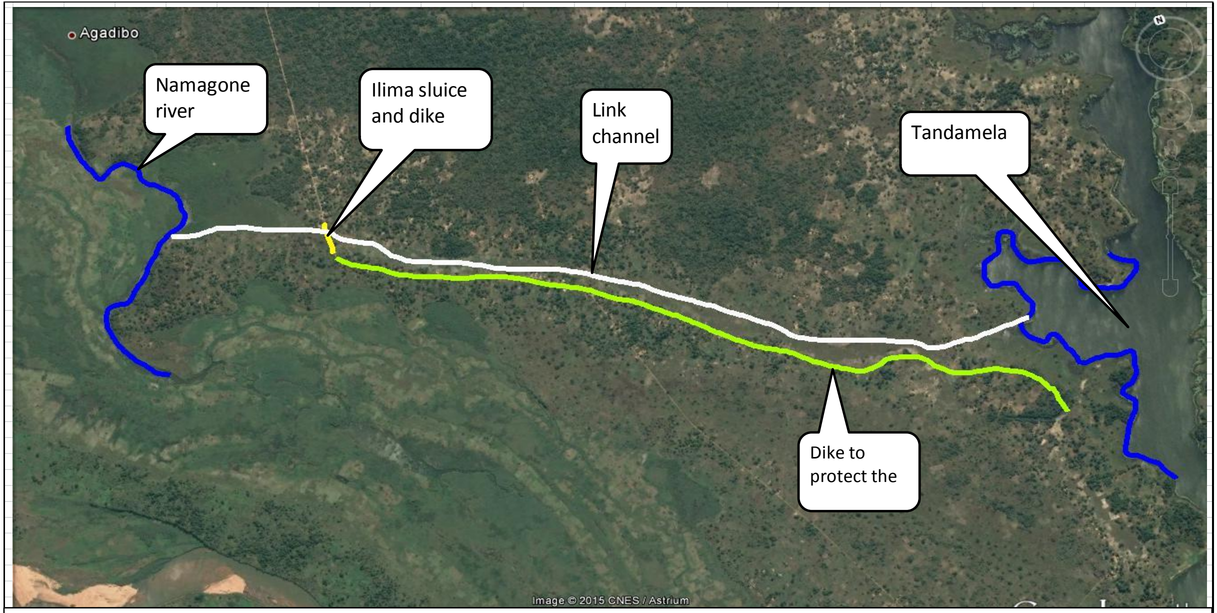


Figure 22 The Future Sluice Complex with Link Channel

The map shows the link channel between the Namagone river and the Tandamela Lake (white line) and the future Ilima dike (green) and sluice (yellow line). The link channel is constructed in a natural flood way of the Licungo river and will have three drop structures. It is obvious that the Ilima dike (situated between two dunes) and sluice complex must be "flood free" to avoid the flood water overtopping the dike and streaming into the channel. This kind of events would provoke major damages and loss of investment. Therefore also a protection dike is planned along the channel, to be constructed with the excavated soil from the channel.

Figure 23 is showing the situation between the Moneia and Nante dunes, also a flood way for the Licungo river. During colonial times a dike was constructed with two wooden bridges crossing the Cune an Naminane Rivers. In 2005 a semi-circular dike was constructed to avoid backward erosion from the Licungo River streaming into the Tandamela Lake during floods. In the first drawing below the map the actual situation is visualized as the DRR-Team was able to observe during the field visit on 15 April 2015. The Naminane Bridge was destroyed. In the second drawing the proposed future situation is shown. The Cune and Naminane Rivers will be blocked to enable water storage in the Tandamela lake. A second sluice complex will be constructed to regulate the outflow to the irrigation scheme. The first part of the dike will ideally be at such a level that a flood like the January 2015 flood will not over topping the dike crest. At the second part of the dike the level will be kept low providing space for the Licungo River during floods to stream into the Tandamela Lake and use the lake for flood water storage.

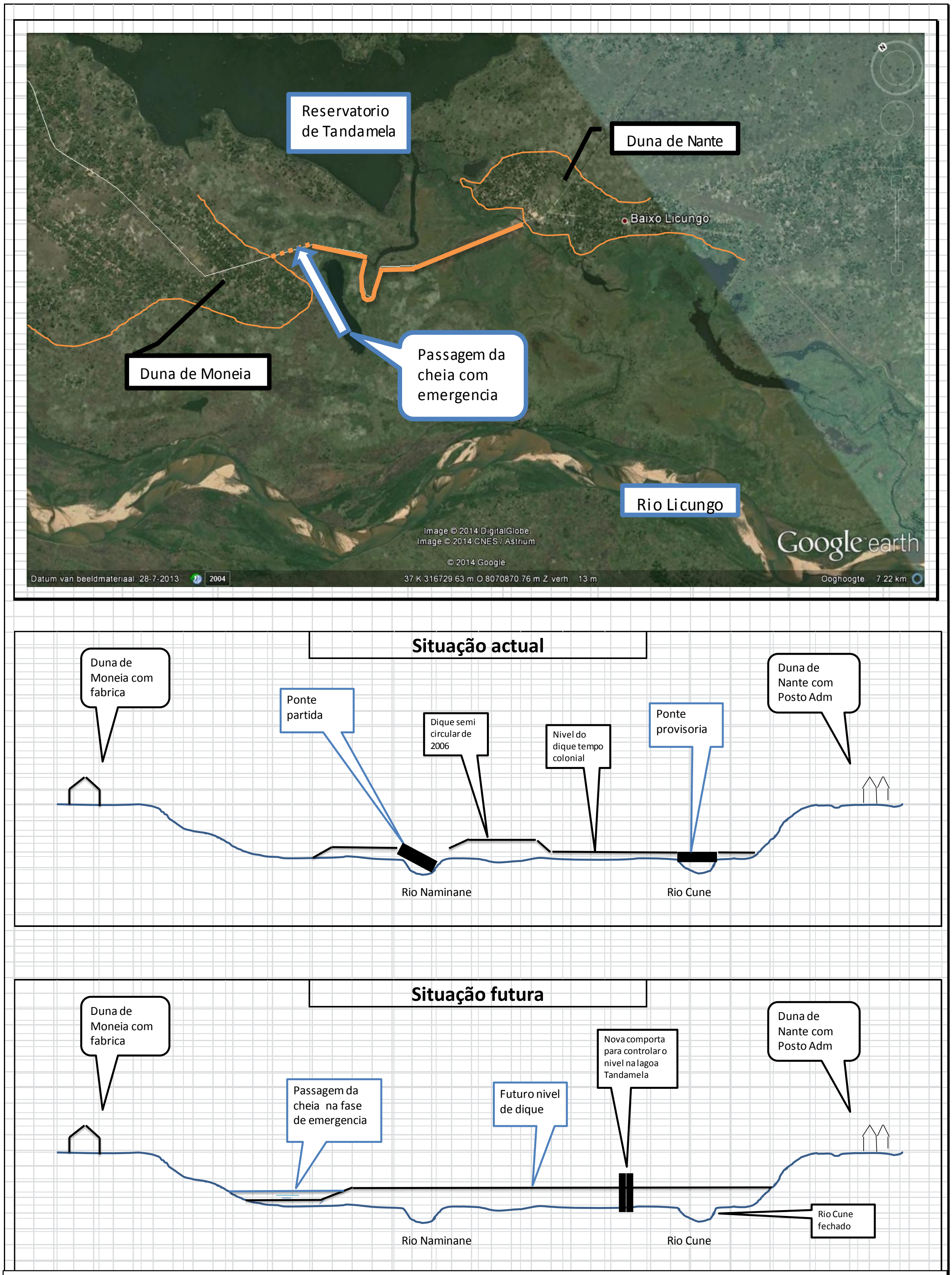


Figure 23 Irrigation Control Structure between the Moneia and Nante Dunes

The exact design height of the different dike elements will need careful additional study: the flood was very high and a dike with such level may not be economically feasible and might. It is essential to determine the return period of the 2015 flood and equilibrium must be sought between design heights, return period, in combination with dike profiles which allow overtopping without damage. Generally, agriculture crop damages are accepted at a frequency of 1 in 5 years when dealing with droughts. In such case the infrastructure of the irrigation system is not affected. In the case of floods however, crop damages may be higher, whereas there are additional damages to the irrigation and drainage infrastructure. Most likely this leads to the acceptance of a lower frequency of flood events, in which case it is necessary to construct a robust infrastructure which minimizes damages resulting from the overtopping of dikes. This applies both to the dike bodies as to infrastructure for irrigation, such as pumping stations and secondary and tertiary irrigation and drainage canals.

In Figure 24 an overall map of the Lower Licungo is shown. The dike system is projected protecting Munda Munda (and the second block of the Munda Munda project called Navicote) and the Intabo irrigation scheme. The white arrows are showing the flood ways of the river.

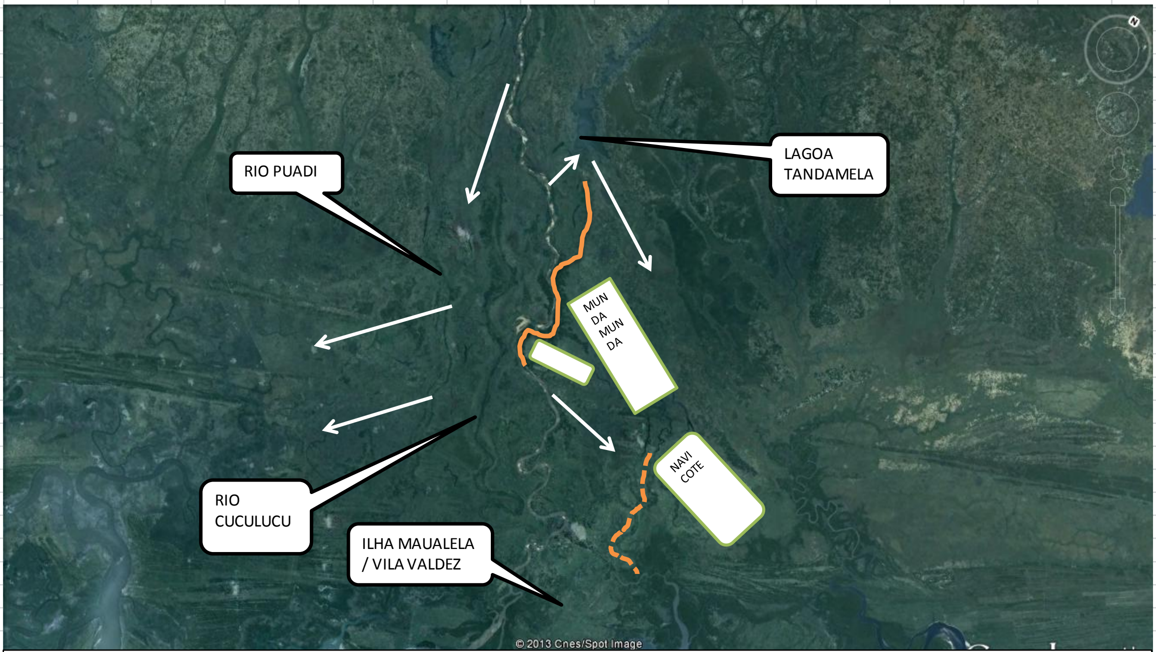


Figure 24 Overall Map of the Lower Licungo showing Munda Munda and Navicote irrigation development

A combination of "strong dikes" not to be overtopped and lower dikes which allow overtopping without structural damage by extreme floods are necessary. This necessitates urgent further study to provide a sustainable flood strategy.

Adjusted time frame implementation Munda Munda project

Figure 25 gives a first idea of the time planning of the various studies and repair activities in relation to the implementation of the Munda Munda project. The ToR of the study: "Preparation of the Strategic Development of a Water Management Plan for the Licungo River Basin" did not include the development a of flood routing model to simulate the different strategies for dike building; that is why a separate flood routing study is proposed. The outcomes of the flood routing study will be used as input for the tender of the detailed design of the river works in the Munda Munda project. The last six months of 2015 the preparatory activities (house & office building, reconstruction of access road etc.) of the Munda Munda project are planned.

		2015		2015		2015		2015		2015		2015		2015		2015		2015		2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016	2016
ACTIVITY		A		M		J		J		A		S		O		N		D		J	F	M	A	M	J	J	A	S	O	N	D
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2												
DRR Mission			■	■																											
River basin study							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Flood routing study										■	■	■	■	■	■	■	■	■	■	■											
Tender for dike repair						■	■	■																							
Contract contractor									■	■	■																				
Mobilization and begin of dike repair works												■	■																		
Repair of dike system														■	■	■	■	■	■												
MUNDA MUNDA PROJECT																															
Munda Munda implementation phase								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Preparation works/ houses and offices									■	■	■	■	■	■	■	■	■														
Tender for river works																				■	■	■									

Figure 25 Adjusted Time Frame for the Implementation of the Munda Munda Project

ANNEX J – OBSERVATIONS ON DIKE REPAIR AND MAINENANCE

Present practice on dike repairs

Generally, dike repairs consist of restoring dikes to the same situation (and level) as before the last flood. This has been observed in other river basins and seems to be practised in the Licungo basin.

The original dike level was chosen with respect to protecting the people, their goods and fields and was linked to a certain recurrence of flood levels, for example a 20 years return period. During the years however the level of the dikes subsides because of wear and tear, rainwater erosion and planting crops on top of the dikes and compression by traffic. Every time the dike is repaired the level is lower because of above mentioned practice, thereby in effect decreasing the return period of the floods. One of the causes of this practice is the fact that no future plans for protection are available and the time to execute the repairs and or bigger works is short, limited to practically one dry period.

Lack of maintenance is often another cause of degradation of the dikes. Frequently used passages lower the dike level and cause initial overflow. Agriculture practiced on the dike surface (crest and slopes) degrade the surface seriously and causes rapid lowering of the protection level.

In order to break this cycle of repetition and degradation, the local authorities and stakeholders should develop plans for the future and define the degree of protection of the people and their goods. Works resulting from these plans should be executable in tranches with duration of one or more dry seasons. In future dike building the authorities need to keep in mind that the river need much room during major floods. So dike location and levels need to accommodate passage of floods, for instance by construction of dikes that may be overtopped without damage.

Responsibility for Dike Management

The existing dikes serve one purpose or a combination of more than one purposes at the time, protection of the habitat, protection of agricultural fields, canalizing water to irrigation schemes and/or a road connection between villages, which are often located on higher ground

The function, or main function, of a dike might serve as indicator for who is responsible for the building, operation, repair and maintenance of it and its works of art (bridges, culverts, valves, etc.) In several river basins it was observed that it was not clear who is the responsible party. Lack of ready available funds is also a cause of delays in maintenance and repairs.

In the case of the Licungo basin it became clear that the major part of the dikes visited have a mixed function for agriculture and road. Therefore it was very much appreciated that the DRR-Team was accompanied not only by DNA and ARA personnel but also by staff working for agricultural institutions.

One suggestion may be that the Government opts for the creation of a specialized organization that treats all dikes and raises funds by all stakeholders by using a participation key to assess the value to be provided by each party.

New building and design.

In order to keep costs, low many dikes have been built with material found nearby. Those materials are not always the best solution for dike building with serious consequences for the life span of these dikes. In the case of need of quick emergency repairs before the next rainy season this practice may be the only option. For new building or extensive overhaul of dikes, a study should be done so as to find the soil with optimum characteristics. The budget for dike (re)building should allow for transportation over bigger distances. In populated areas the digging of borough pits next to the dike will cause a danger for the inhabitants and is to be avoided (this is the case in the areas of Muguloma and Morla).

The slopes of the existing, older dikes, have a gradient of 1 vertical to 1 or 1,5 horizontal (1:1 or 1:1,5). In case of overtopping by floods these slopes are known for their rapid erosion and severe damage. Better results have been observed when slopes with gradient of 1: 2 or more are used. Although these slopes represent a much bigger volume and therefore more investment costs, the damage by overtopping is much less and maintenance and repairs are easier and less costly. Also, the stability of the dike body increases considerable when softer slopes are used.

Maintenance of Dike Crest and Slopes.

Safeguarding and caring for the condition of the dikes includes maintenance of its crest and slopes during the dry season, in which earth works are relatively easy to execute. The whole year round inspections should report on the actual conditions of the dike so as to allow preparation of routine repairs in due time and knowing where the weak spots are located before a new flood will surprise the population again. By means of regular inspection of all dikes, the responsible entities are prepared to cope with timely evacuation and measures to limit the damage. All information gathered should be stored in digital systems on-line, accessible for all stakeholders.

In practice the maintenance includes the following activities:

a. Regular inspection and registration and mapping of findings;
b. Organising the stakeholders for manpower and arranging funds for the execution of small repairs;
c. Maintain the gradient of the dike slopes between 1:2 and 1:2.5 (V:H)
d. Organise the planting and extending slope cover by protective vegetation (Vetiver, Bambo, crawling grass) using manpower of the stakeholders. Bamboo and crawling grass are often locally available. Elephant grass is a locally available plant that spreads fast and may close the access for inspection and maintenance of the slopes and dike tops;
e. Prohibit the practice of agriculture on the dike crest and slopes;
f. Repair holes and burrows dug by animals in the dike gradients;
g. Avoid the growth of trees in the dike body, especially in windy areas;
h. Repair and level local depressions and wear and tear caused by frequent passing on same spot by cattle;
i. Avoid cattle and goats trotting on the dikes and pulling out the vegetation;
j. Stimulate the use of sheep who will compact the earth and do not pull out the roots of the vegetation but only keep it short.

The above activities do not need the intervention of a contractor and can be executed by the local population and stakeholders as a contribution to their own interest. By mobilising these activities regularly, the amount of work will remain limited, however, damages caused by big floods will need more extensive repair works.

Slope Protection by Plants and Grasses

Before choosing the best type of protection of the slopes several questions need to be answered:

a. Is the dike also a road? If so the crest should remain clean of high and strong grasses. In case of curves in the road the grass on the slopes should be kept short so as to avoid bad visibility and dangers;
b. Is the gradient of the slope sufficient to assure the growth of the grass? For stability and reduction of vulnerability to erosion, slopes of 1: 2 to 1:3 (V:H) will will generally suffice. However the costs involved in these slopes is considerably higher than the until now used 1:1 or 1:1.5;
c. Are there animals around that like to eat the grass? Goats have the habit to pluck plant and root out of the soil. Sheep and cows eat only what is above the ground. Protection of the slopes by fences has been subject of long discussions. In practice the fences need gates for local traffic and passage. Sometimes fences are taken away by people to be used for house building or other private means, and need to be replaced. If the fence makes sense it should run along the two sides of the dike close to its toe and along the length of it, which may be several kilometres;
d. Are there species of grass locally available that may serve the purpose and that can be placed and maintained by the beneficiaries of the dikes (Farmer Associations)? If so these local solutions merit a strong preference above importing techniques and products against foreign currency. Professional advice may be sought and used for a systematic approach for slope protection techniques;
e. As the agricultural zones in question have to survive on very low cost solutions and self-supporting techniques the costs component of the solution to be chosen should be studied in detail and local experience should be used so as to avoid costly scientific solutions that will become obsolete or be abandoned rapidly.

Dike Inventory and Mapping

As dikes constitute important infrastructure for the protection of life and goods and are a means of connection for people and transport of goods it is important that complete documentation be kept of all dike sections and their history and present state. During the mission no such systematic documentation was shown and no maps were used in the field for orientation and localisation/noting of findings. Prints of GOOGLE EARTH maps were not used in the field but only in the office.

Information about dikes and breaches is stored in the heads of the staff, a fact that is very valuable but often not accessible other people, DRR-Teams, financers and. All over the world databases and maps are used to enable communication and consultation of information in seconds. Everywhere, also in field work, computers and GPS are nowadays used to store, combine and use information. In 2013 the position of dikes in the Licungo Basin had not been entered in such system.

Topographical surveys should be executed to know dike, road, structure and field levels permitting to monitor degradation of the levels over the years and to identify the lowest places where overtopping problems will occur first.

It is strongly advised that modern systems be used to a greater extent so as to have information ready at hand; analysis of the past already made, GPS readings of every problem location entered; breach length to be measured by GPS; dike levels and first overtopping areas known; level gauges need to be extended to higher levels and continuous reading during flood peaks.

Looking Forward

The Licungo river basin is an area with much agricultural potential. Several projects, financed by international institutions and by private initiatives, are starting up or are being prepared. All these projects need water, requiring integrated planning to serve all users and future users of the water of the Licungo in a sustainable way. A Master Plan needs to be prepared for the future use of the potential of the basin.

Integrating the Interests of Different Stakeholders

In this mission representatives of agriculture were included which has strongly stimulated the cooperation. More stakeholders will be interested to participate in discussions about the building and maintenance of dikes for the necessary road connections and the protection of human life, good, crops and eventually small industries.

Time Constraints with Regard to Repair Activities

The damage caused by floods necessitates the organisation of repair works and the raising of the funds. Up to date a small part of the total funds needed for repair of dikes came from the Mozambican Government, which finds are generally quickly available. However, the necessary additional internationally arranged funds tend to be available much later, causing the available time frame for execution to shrink to only one, two or three months before the start of the next rainy season. Therefore it is suggested that the Government and responsible entities arrange for the setting up a structural "Dike repair fund" so as to enable quick response in times of emergency with short and transparent procurement procedures.

Standardised contracts and bills of quantities should be ready for use at all responsible entities. Specifications can also be standardized and are already available at DNA and ARA-Sul. For the correct completion of the B.O.Q. and some other documents, a survey should be done as soon as access to the field is safe. In many places measurements of the damage can be done before all water resides. The location of borough pits can be known beforehand by systematic study during dry seasons, which should be stored in a database. The short time available for execution of works and limited funds will favour the solution of using soils from close by, next to the dike. This practice should be avoided because it will cause dangers in populated areas and undermine the stability of the dike. The funds should allow for hauling soils from bigger distances otherwise the above mentioned practice will prevail .

In the case of Muguloma and Morla the road between the indicated borough pit (by Jan de Moor) and the works will need extensive repairs before being able to carry heavy means of transportation.

ANNEX K – COST ESTIMATE OF DIKE REPAIR BASED ON FIELD VISIT

The dimensions of the breaches have been estimated by Henk Karsten and Xavier Cafferman independently. The unit price of 50 USD/m3 for general dike building, used by the World Bank, was used for this cost estimate.

Breach #	Date	Area	Estimated Dimensions L(m)	W(m)	H(m)	Volume M3	Unit price USD	Est. Value USD
1	15/04/2015	Naminane Ponte	28	18	6	3,024	50	151,200
2	15/04/2015	Naminane Ponte Betão	30	6	0.35	63	450	28,350
3	16/04/2015	Dique Valintim	14	8	1	112	50	5,600
4	16/04/2015	Dique Valintim	7	8	2	112	50	5,600
5	16/04/2015	Dique Valintim	4	5	1.5	30	50	1,500
6	16/04/2015	Dique Valintim	35	8	1.85	518	50	25,900
7	16/04/2015	Dique Valintim	32	8	1.82	466	50	23,296
8	16/04/2015	Dique Valintim	16.2	8	1.7	220	50	11,016
9	16/04/2015	Dique Valintim	4	4	1.65	26	50	1,320
10	16/04/2015	Dique Valintim	23.5	8	1.82	342	50	17,108
11	16/04/2015	Dique Valintim	50	8	1	400	50	20,000
12	16/04/2015	Dique Valintim	15	8	0.75	90	50	4,500
13	16/04/2015	Dique Valintim	35	11	2	770	50	38,500
14	16/04/2015	Dique Valintim	35	11	3.6	1,386	50	69,300
15	16/04/2015	Dique Valintim	30	20	3	1,800	50	90,000
16	16/04/2015	Dique Valintim	100	25	5	12,500	50	625,000
17	16/04/2015	Dique Valintim	10	6	1.5	90	50	4,500
18	16/04/2015	Dique Munda Munda	35	25	2.5	2,188	50	109,375
19	16/04/2015	Dique Munda Munda	20	20	2.5	1,000	50	50,000
20	16/04/2015	Dique Munda Munda	70	15	2.5	2,625	50	131,250
21	16/04/2015	Dique Munda Munda	90	20	3.3	5,940	50	297,000
22	Info add.	Dique Munda Munda	153	12	3.7	6,793	50	339,660
23	Info add.	Dique Munda Munda	53	12	2.5	1,590	50	79,500
24	Info add.	Dique Munda Munda	533	12	2.5	15,990	50	799,500
25	16/04/2015	Estrada Eribacila	20	20	2	800	50	40,000
26	16/04/2015	Estrada Eribacila	30	30	1	900	50	45,000
27	16/04/2015	Estrada Eribacila	4	4	1	16	50	800
28	16/04/2015	Estrada Eribacila	5	3	1	15	50	750
29	16/04/2015	Estrada Eribacila	2	2	1	4	50	200
30	16/04/2015	Estrada Eribacila	8	8	3	192	50	9,600
31	Info add.	Dique Eribacila	270	11	3	8,910	50	445,500
32	Info add.	Breach Eribacila (Downstream left)	35	15	2	1,050	51	53,550
33	Info add.	Transtportation soils	Distance	1.5	km	11,887	3	35,661
34	Info add.	Eribacila concrete works	40	1	5	200	450	90,000
35	16/04/2015	Estrada Morla	8	8	0.5	32	50	1,600
36	16/04/2015	Estrada Morla	25	8	1.8	360	50	18,000
37	16/04/2015	Estrada Morla	8	8	1	64	50	3,200
38	16/04/2015	Estrada Morla	4	2	1	8	50	400
39	Info add.	Morla Berma do rio	15	6	6	540	50	27,000
40	Info add.	Morla Berma do rio gabiões	15	1	6	90	250	22,500
41	16/04/2015	Morla	20	20	2.5	1,000	50	50,000
42	16/04/2015	Morla	20	20	1.5	600	50	30,000
43	Info add.	Morla Cameras de Empres.	Distance	4	Km	17,375	3	208,500
44	16/04/2015	Muguloma	10	3	1	30	50	1,500
45	16/04/2015	Muguloma	10	10	2.5	250	50	12,500

Breach #	Date	Area	Estimated Dimensions L(m)	W(m)	H(m)	Volume M3	Unit price USD	Est. Value USD
46	16/04/2015	Muguloma Berma do Rio	70	15	3	3,150	50	157,500
47	16/04/2015	Muguloma Berma do Rio gabiões	70	1	6	420	250	105,000
48	16/04/2015	Muguloma Berma do Rio	25	5	6	750	50	37,500
49	16/04/2015	Muguloma Berma do Rio gabiões	30	1	6	180	250	45,000
50	16/04/2015	Muguloma Berma do Rio	50	10	6	3,000	50	150,000
51	16/04/2015	Muguloma Berma do Rio gabiões	60	1	6	360	250	90,000
52	16/04/2015	Muguloma Berma do Rio	100	4	2	800	50	40,000
53	16/04/2015	Muguloma Berma do Rio gabiões	30	1	6	180	250	45,000
54	16/04/2015	Muguloma	15	8	2	240	50	12,000
55	16/04/2015	Muguloma Berma do Rio gabiões	25	1	6	150	250	37,500
56	16/04/2015	Muguloma	15	15	2.5	563	50	28,125
57	Info add.	Muguloma Berma do Rio gabiões	30	1	6	180	250	45,000
58	Info add.	Muguloma Cameras de Empres.	Distance	6	Km	4,225	3	76,050
59	16/04/2015	Intabo Estação	20	20	3	1,200	50	60,000
60	16/04/2015	Intabo Dique original	150	18	6	16,200	50	810,000
61	Info add.	Transtportation soils	Distance	6.5	Km	17,400	3	52,200
62	16/04/2015	Intabo Berma do rio gabiões	120	1	6	720	250	180,000
63	16/04/2015	Topo da Estrada	5000	6	0.3	9,000	50	450,000
			Total Earth Works			**127,366**		**6,446,111**
			Margin(%)		20	**152,839**		**7,735,333**

Note 1: The items marked "Info Add" in the column "date" were incorporated after having received additional information from Jan de Moor. These breaches were not visited in the field due to inaccessibility.

Note 2: The dike and the bridge are to be incorporated in the new irrigation project. The design, the function and the responsibility for these infrastructures has not yet been determined definitively, pending recommendations from this mission.

Note 3: The concrete works were not included. The infrastructure in concrete of pump stations and inlet valves was considered to be the responsibility of Agriculture, with two exceptions, Breach/Bridge # 2, being part of the road connection between Nante, Monei and Ilima. # Breach 34 is of importance for allowing farmers to cross the river Cune.

Note 4: The berm of the river in the area of Morla, Mugulomaneeds and Intabo reinforcement so as to avoid falling into the river. The erosion at this site is aggressive and will reoccur, threatening the road and the houses. In the long term bigger works have to be foreseen or the layout of the road will have to be adapted to the progress of the erosion of the berm. A consequence will be the need to re-construct the houses in another place. In the table the placement of gabions is foreseen. The stones for the filling can be found at a distance of about 30 KM. Refers to # Breaches 40, 47, 49, 51, 53, 55, 57 and 62.

Note 5: The gabions have to be covered by a layer of mortar so as to avoid pilferage of the iron mesh.

Note 6: The filling of the borough pits, # breaches 43 and 48, is considered necessary for the security of the inhabitants as well as for safeguarding the stability of the dikes. The material needs to be transported from a considerable distance.

ANNEX L - LITERATURE

Some of the literature is not in its final form:

- Preliminary report: "Proposta de Soluções para Prevenir e Reduzir os Efeitos das Calamidades Naturais a Médio e Longo Prazo" (Proposal to prevent and reduce the consequences of natural disasters in the medium and long term). Ministério da Administração Estatal e Função Pública, Conselho Técnico de Gestão de Calamidades, 29 March 2015.
- Descrição das Cheias em Nante, Jan de Moor and Braz E. Anselmo, February 2013.
- Mozambique 2015: damage assessment and early recovery / sustainable reconstruction priorities Joint rapid assessment following the January-February 2015 hydro-meteorological events in Central and Northern Regions, March 30, 2015
- Janeiro 2015 Cheia no Rio Licungo, 2015/1/31, Assistência Para o Fortalecimento da Capacidade Institutional na Gestão dos Riscos de Disastros Relacionados com Água em Moçambique, Makoto KODAMA, DNA.
- Danos Resultante de Chuvas intensas acompanhadas de trovoadas e ventos fortes, nas províncias de Niassa, Nampula e Zambézia, Instituto Nacional de Meteorologia, Rua de Mukumbura nº 164, Caixa postal – 256, Maputo – Moçambique, 8 April 2015
- Multi-Annual Strategic Plan 2014-2017, Transformation; new opportunities, new challenges! Netherlands Government, October 2013.
- Terms of Reference for "Elaboração do Plano Estratégico de Desenvolvimento e Gestão de Recursos Hídricos da Bacia Hidrográfica do Rio Licungo", DNA, January 214
- Scoping MIssion on Technical Assitance fro Improved Flood Mitigation through Intergrated Land and Water Management in the lower Zambezi Valley, Final Report Flood Mitigation Mission Team, The Netherlands, Maputo, 15 June 2013
- Visão da DNA sobre Passos a Seguir & Expectativas, powerpoint presentation on expected Technical Assistance, April 2015.
- Acções para Redução da Vulnerabilidade das Cheias em Moçambique, powerpoint presentation on actions and vision, DNA, April 2015
- Building Blocks for Good Water Governance, Herman Havekes, Maarten Hofstra, Andrea van der Kerk, Bart Teeuwen, Water Governance Centre, The Hague, 2013
- Integrated Flood Management for the Limpopo Basin in Mozambique – Scoping Paper, Arcadis, WATERWYS, Hoogheemraadschap Rijnland, February 2014
- World Bank: Aid Memoire Flood Rapid Assessment Licungo River, Mozambique, P155440, Adri Verwey, June 2015