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Report No: 75939-MZ

INTERATIONAL DEVELOPMENT ASSOCIATION

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED GRANT

IN THE AMOUNT OF US$15 MILLION

FROM THE PILOT PROGRAM FOR CLIMATE RESILIENCE (PPCR)
OF THE STRATEGIC CLIMATE FUND (SCF)

TO

THE REPUBLIC OF MOZAMBIQUE

FOR A

CLIMATE RESILIENCE: TRANSFORMING HYDROLOGICAL AND METEOROLOGICAL SERVICES PROJECT

April 01, 2013

Environment, Natural Resources, Water and
Disaster Risk Management Unit (AFTN3)
Sustainable Development Department
Country Department, AFCS2
Africa Region

CURRENCY EQUIVALENTS

(Exchange Rate Effective February 20, 2013)

Currency Unit = Mozambican Metical
30.44MZN = US$1

FISCAL YEAR

January 1 to December 31

ABBREVIATIONS AND ACRONYMS

ARA	Regional Water Authority (Administração Regional de Águas)
ARA-Sul	Southern Regional Water Authority (Administração Regional do Águas de Sul)
BCA	Benefits Costs Analysis
CIFs	Climate Investment Funds
CNA	National Water Council (Conselho Nacional de Águas)
CPS	Country Partnership Strategy
CRA	The Council for the Regulation of Water Supply (Conselho de Regulação do Abastecimento de Água)
CUT	Single Treasury Account (Conta Única do Tesouro)
CWRAS	Country Water Resources Assistance Strategy
DA	Designated Account
DRH	Department of Water Resources (Departmento de Recursos Hídricos)
DNA	National Directorate of Water (Direcção Nacional de Águas)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
ENGRH	National Water Resources Management Strategy (Estratégia Nacional de Gestão de Recursos Hídricos)
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Management Framework
FEWS NET	Famine and Early Warning System Network
FIPAG	Fund for Water Supply Investments and Assets (Fundo de Investimento e Património de Abastecimento de Água)
FMS	Financial Management Specialist
GFDRR	Global Facility on Disaster Reduction and Recovery
GoM	Government of Mozambique
HCB	Cahora Bassa Hydropower Plant (Hidroeléctrica de Cahora Bassa)
IACM	National Institute for Civil Aviation (Instituto de Aviação Civil de Moçambique)
IDA	International Development Association
IDPPE	Insistute for Development of Artisinal Fishery (Instituto de Desenvolvimento de Pesca de Pequena Escala)
IFRs	Interim Unaudited Financial Reports
IIAM	Mozambique Institute for Agrarian Research (Instituto de Investigação Agrária)
INAHINA	National Institute for Hydrography and Navigation (Instituto Nacional de Hidrografia e Navegação)
INAM	National Meteorological Institute (Instituto Nacional de Meteorologia)
INAMAR	National Maritime Authority (Instituto Nacional da Marinha)
INGC	National Institute for Disaster Management (Instituto Nacional de Gestão de Calamidades)

JTOC	Joint Technical Operational Committee (Mozambique, Zambia and Zimbabwe)
LA	Environmental License (Licença Ambiental)
M&E	Monitoring and Evaluation
MAR	Mean Annual Runoff
mASL	Meters Above Sea Level
MICOA	Ministry for Coordination of Environmental Affairs (Ministério para a Coordenação da Acção Ambiental)
MOPH	Ministry of Public Workings and Housing (Ministério das Obras Públicas e Habitação)
MPD	Ministry of Planning and Development (Ministério da Planificação e Desenvolvimento)
MTC	Ministry of Transport and Communication (Ministério dos Transportes e Comunicações)
NDF	Nordic Development Fund
NPV	Net Present Value
O&M	Operation and Maintenance
PAMT	Project Administration and Monitoring Team
PARP	Poverty Reduction Action Plan (Plano de Acção para a Redução da Pobreza)
PDO	Project Development Objective
PIM	Project Implementation Manual
PA	Water Policy (Política de Águas)
PAMT	Project Administration and Monitoring Team
PNDA	National Water Development Program (Programa Nacional de Desenvolvimento de Águas)
PPCR	Pilot Program for Climate Resilience
PRIMA	Progressive Realisation of the IncoMaputo Agreement
PRONASAR	National Rural Water Supply and Sanitation Program (Programa Nacional de Abastecimento de Água e Saneamento Rural)
RPF	Resettlement Policy Framework
SADC	Southern African Development Community
SADCHYCOS	SADC Hydrological Cycle Observation System
SAMPRO	Southern Africa Meteorology Project
SARCOF	Southern Africa Climate Outlook Forum
SDR	Special Drawing Rights
SIA	Social Impact Assessment
SIL	Specific Investment Loan
SPCR	Strategic Programme for Climate Resilience
UGEA	Procurement Unit (Unidade Gestora e Executora de Aquisições)
ZAMCOM	Zambezi Watercourse Commission
ZESCO	Zambia Electricity Supply Corporation
ZRA	Zambezi River Authority
WMO	World Meteorological Organisation

Regional Vice President:	Makhtar Diop
Country Director:	Laurence C. Clarke
Sector Director:	Jamal Saghir
Sector Manager:	Magda Lovei
Task Team Leader:	Marcus Wishart / Louise Croneborg

MOZAMBIQUE

Pilot Programme for Climate Resilience:
Transforming Hydro-Meteorological Services Project

TABLE OF CONTENTS

PAD DATA SHEET

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services

PROJECT APPRAISAL DOCUMENT

Africa

AFCS2

Date:	April 01, 2013	Sectors:	General water, sanitation and flood protection sector (80%); General agriculture/ fish/ forestry sector (20%)
Country Director:	Laurence C. Clarke		
Sector Manager:	Magda Lovei	Themes:	Water resource management (30%); Other environment and natural resources management (30%); Other rural development (20%); Climate change (20%)
Sector Director:	Jamal Saghir		
Project ID:	P131049		
Lending Instrument:	Grant	EA Category:	B
Team Leader(s):	Marcus Wishart / Louise Croneborg		

Recipient:	The Republic of Mozambique		
Responsible Agency:	The National Directorate of Water (DNA, Direcção Nacional de Águas)		
Contact:	Suzana Saranga Loforte	Title:	National Director
Telephone No.:	+258 21 31 25 71	Email:	ssaranga@dnaguas.gov.mz
Responsible Agency:	The National Institute for Meteorology (INAM, Instituto Nacional de Meteorologia)		
Contact:	Moises Vicente Benessene	Title:	National Director
Telephone No.:	+258 21 49 31 93	Email:	moises_b@inam.gov.mz

Project Implementation Period:	5.5 years	Start Date:	April 25, 2013	End Date:	December 31, 2018
Expected Effectiveness Date:	June 30, 2013				
Expected Closing Date:	December 31, 2018				

Project Financing Data(US$M)

[ ] Loan [X] Grant [ ] Credit [ ] Guarantee [ ] Other

Financing Source		Total Amount (US$ million)
Total Project Cost :		**US$22.50 million**
Total Bank Financing	Pilot Program for Climate Resilience	US$15.0 million
Parallel Financing	Nordic Development Fund	US$6.0 million (€4.5 m)
Recipient	Republic of Mozambique	US$1.50 million

Expected Disbursements (in US$ million

Fiscal Year	FY14	FY15	FY16	FY17	FY18	FY19
Annual	1.0	2.5	3.5	4.0	3.0	1.0
Cumulative	1.0	3.5	7.0	11.0	14.0	15.0

Project Development Objective(s)

To strengthen hydrological and meteorological information services to deliver reliable and timely climate information to local communities and to support economic development.

COMPONENTS

Component A. Strengthening Hydrological Information Management

The component will support: strengthening and optimisation of the physical hydrological monitoring networks; improving quality control and standards enforcement for hydrological data; data management, modeling, forecasting with flood- and early warning systems, and ICT; skills, capacity-building and training; and development and improved access to information products.

Component B. Strengthening Weather and Climate Information Management

The component will support: strengthening and optimisation of the physical meteorological monitoring networks; improving quality control and standard enforcement for meteorological data; data management, modeling, forecasting, extreme weather prediction and early warning systems and ICT; skills, capacities and training; and development and improved access to information products.

Component C. Piloting resilience through delivery of improved weather and water information

The component will support pilot interventions to enable more effective end-to-end delivery of hydro-meteorological information. The proposed pilots will include: early warning systems and flood forecasting in the Zambezi, Limpopo and Incomati River basins; hydro-meteorological information for farmers in pilot locations in the Gaza and Inhambane provinces; weather service alerts in coastal areas in Inhambane; and innovations for inter-agency delivery of data.

Compliance

Policy

Does the project depart from the CPS in content or in other significant respects?	Yes [ ] No [x]
Does the project require any exceptions from Bank policies?	Yes [ ] No [x]
Have these been approved by Bank management?	Yes [ ] No [ ]
Is approval for any policy exception sought from the Board?	Yes [ ] No [x]
Does the project meet the Regional criteria for readiness for implementation?	Yes [x] No [ ]

Safeguard Policies Triggered by the Project	Yes	No
Environmental Assessment OP/BP 4.01	x	
Natural Habitats OP/BP 4.04	x	
Forests OP/BP 4.36		x
Pest Management OP 4.09		x
Physical Cultural Resources OP/BP 4.11		x
Indigenous Peoples OP/BP 4.10		x
Involuntary Resettlement OP/BP 4.12	x	
Safety of Dams OP/BP 4.37		x
Projects on International Waters OP/BP 7.50		x
Projects in Disputed Areas OP/BP 7.60		x

Legal Covenants			
Name	**Recurrent**	**Due Date**	**Frequency**
Project Implementation Manual: Grant Agreement Article IV 4.01 (a)		June 30, 2013	Effectiveness condition
Description of Covenant: The Project Implementation Manual has been adopted by the Recipient inform andsubstance acceptable to the World Bank .			
Name	**Recurrent**	**Due Date**	**Frequency**
Project Coordinator TOR: Grant Agreement Article IV 4.01 (b)		June 30, 2013	Effectiveness condition
Description of Covenant: The Recipient has submitted to the WorldBank the terms of reference for the Project Coordinator whose substance shall be satisfactory to the World Bank.			

Team Composition

Bank Staff

Name	Title	Specialisation	Unit	UPI
Marcus Wishart	Sr Water Resources Specialist, TTL	Water Resources	AFTN2	279732
Louise Croneborg	Water Resources Management Specialist, Co-TTL	Water Resources, Hydro-Met	AFTN2	351606
Daniel Kull	Sr Disaster Risk Specialist	Hydrology, DRM, WCIDS	GFDRR	379708
Francis S. Nkoka	Disaster Risk and Climate Change Specialist	DRM, Climate Change	AFTN2	382675
George Ledec	Lead Environment Specialist	Environment	AFTN3	014216
Kristine Schwebach	Sr Social Specialist	Social development	AFTCS	160145
Eric Foster-Moore	Operations Analyst	Water Resources	AFTN2	407093
Celia dos Santos Faias	Team Assistant	Administration Management	AFCS2	368252
Angela Dengo	Team Assistant	Administration Management	AFCS2	438321
Antonio Chamuco	Sr Procurement Specialist	Procurement	AFTPC	0222820
João Tinga	Financial Management Specialist	Financial Management	AFTFM	206490
Rafael Saute	Communication Specialist	Communication	AFRSC	249187
Luz Meza-Bartrina	Senior Counsel	Legal	LEGAM	174951
Nadeem Mohammed	Legal Analyst	Legal	LEGAM	231091
José Janerio	Sr Finance Officer	Financial Management	CTRLA	194575
Vladimir Tsirkunov	Sr Environmental Engineer	Climate Services, WCIDS	GFDRR	091773
Hrishikesh Patel	GIS Specialist	GIS	AFTN1	347802

Non Bank Staff

Name	Title	Office Phone	City
Jeff Lazo	Sr Hydro-Met Economist	-	Denver (USA)
Bengt Tammellin	Sr Meteorologist	-	Helsinki (Finland)
Roberto White	Sr Disaster Risk Specialist	-	Maputo (Mozambique)

Locations

Country	First Administrative Division	Location	Planned	Actual	Comments
Mozambique	AFCS2	Mozambique			

I. STRATEGIC CONTEXT

A. Country Context

1. Mozambique is experiencing rapid and sustained economic growth. Between 2001 and 2011, the average GDP growth rate was 7.2%[1] and during 2013 growth is expected to reach 8% as a result of foreign direct investments, expanding extractive industries and infrastructure investments. The productive base of the economy remains narrow and focused on agriculture (which grew at a rate of 8.4%[2] and employed 78% of the population in 2011), industrial mega-projects[3] and extractive industries (which grew by 50% in 2012). Despite macroeconomic achievements, Mozambique has 27% unemployment and remains one of the poorest countries in Africa. Concurrent with rapid economic growth between 2003 and 2009, the proportion of population living in absolute poverty in Mozambique fell from 56.4% to 52.1%. Today, the average per capita income is estimated at US$458[4] among its 23 million people, and in the UNDP's Human Development Index the country ranks 184 of 187. Average life expectancy is 49.7 years, 43.7% of children under five are malnourished, and child mortality is one Africa's highest[5]. Human wellbeing is also challenged by highly unequal access to water in urban and rural areas (77% and 29% respectively), and the prevalence of diseases such as malaria and HIV/AIDS[6]. Further, MDG-progress at national level masks regional variations where poverty and food insecurity are pervasive at local levels.

2. Mozambique is the third country most at risk from water and weather-related hazards in Africa[7]. As much as 58% of the population and more than 37% of GDP risk exposure to two or more natural hazards - translating into 1.1% annual average loss in GDP. In 2000, Cyclone Eline hit southern Mozambique and caused loss of lives and livelihoods, and damages equivalent to 20% of GDP. Due to floods in January 2013 that affected southern Mozambique, over 200,000 people have been displaced and over 90 lives have been lost. With more than 60% of the Mozambican population living in low-lying, topographically flat areas and in coastal zones, exposure to floods and cyclones is high and even small changes in sea level or river flow have far reaching impacts. In economic terms, floods cause annual average losses in the order of US$17.5 million in loss of household/shelter, US$0.7 million in damage of roads, and US$42.5 million for loss in the staple crop maize.

3. In scenarios developed through the Intergovernmental Panel on Climate Change (IPCC) and the Global Circulation Models, significant changes in climate patterns are predicted in Mozambique. Rainfall patterns are predicted to vary across the country. In some locations, rainfall may decrease by 31% and in others by 16%. The rainy seasons could shorten and droughts be prolonged, especially in central regions. Sea level rise could reach 2.17mm/yr in the southern populated areas of Maputo (±0.76mm/yr)[8] and temperatures increase by 1-2°C by the year 2050. Climate change could result in GDP losses of 4-14% relative to its expected growth

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[1] http://www.africaneconomicoutlook.org/en/countries/southern-africa/mozambique
[2] World Bank *Mozambique Economic Update* (September 2012)
[3] Ibid. Mega Projects are responsible for 46% of trade.
[4] UNFPA *Mozambique: Social and Demographic Indicators* (2012)
[5] 135 per 1,000 live births. UN Group for Child Mortality Estimation - UNICEF, WHO, World Bank, UN DESA, UNPD (2010)
[6] An estimated 13.1% of women and 9.2% men in Mozambique are hiv-positive.
[7] Global Facility for Disaster Reduction and Recovery *Mozambique Country Profile* (2009)
[8] IPCC *Climate Change 2007: impacts, adaptation and vulnerability* (Cambridge University Press, 2007)

by the year 2050. In order to protect and enhance economic gains, build future climate change resilience and more effective management of water resources and weather conditions, the Government of the Republic of Mozambique has set out to strengthen its hydrological and meteorological information services.

B. Sectoral and Institutional Context

4. The Government of Mozambique's (GoM) hydrological and meteorological information services can play an important role in safeguarding the macro-economic gains made to date by delivering accurate, accessible and relevant information on water and weather. Hydro-met information provides a foundation for early warning systems that can prevent losses, for enhancing productivity of key sectors, and for building resilience to the negative impacts of climate change.

5. Mozambique experiences some of southern Africa's most variable hydrological and meteorological (hydro-met) conditions. Tropical to sub-tropical climates prevail in the northern and central regions, whereas a dry, arid desert climate predominates in the south. The oscillations of the Inter-Tropical Convergence Zone and the El Niño/a phenomena influence the timing and magnitude of rainy seasons (lasting October to March, 25-27°C) and dry winter seasons (April to September, 20-25°C)[9]. The national average rainfall of 1,032mm/yr[10] varies across seasons with 60-80% of rain falling between December and March[11]. Precipitation also varies spatially, where the wetter north can receive 1,000-2,000mm/yr compared to 500mm/yr in the south. In contrast, frequent droughts affect the southern provinces and central areas along the Zambezi River valley (7 in 10 and 4 in 10 years respectively[12]). With a low-lying topography and a coastline of 2,470km, Mozambique is particularly exposed to tropical cyclones. Warm-core air centers arise over the Indian Ocean and the Mozambique Channel and move westward towards the mainland, bringing heavy downpours and wind gusts that can reach 300km/hr in velocity. In terms of water, Mozambique has some of Africa's largest total renewable water resources (216km^3/yr) [13]. The country is the final downstream riparian in nine of its 13 major river basins (≥10,000km^2), and thus more than 50% of the country's total-mean-annual runoff is generated outside Mozambique's boundaries. Upstream activities and neighboring weather/water conditions directly affect the country. The rainfall extremes, combined with limited storage and flood-control infrastructure, result in frequent flooding and variable inter-annual river flows.

6. Improvements to Mozambique's hydro-met services have the potential to enhance productivity in sectors such as agriculture, fishery/maritime, hydropower, aviation, road transportation, infrastructure planning and health. Subsistence rain-fed farming provides livelihood, income and food for almost 80% of the population. Collectively, land farmed for subsistence agriculture represents 97% of total cultivated land. However, only 4% of the agriculturally viable 2.7 million hectares is equipped with irrigation infrastructure[14]. Aquaculture, commercial fisheries and artisanal fishers depend on timely meteorological information to avoid dangerous storms and the resulting loss of life and physical resources such

[9] http://www.fao.org/nr/water/aquastat/countries_regions/mozambique/index.stm
[10] McSweeney et al. *Mozambique: UNDP Climate Change Profile* (2011)
[11] See Annex 10 for illustration.
[12] Global Assessment Report on Disaster Risk Reduction (2011)
[13] Surface waters constitute the majority of resources. World Bank *Country Water Resources Assistance Strategy* (2007)
[14] World Bank *Zambezi River Basin Multi Sector Investment Opportunities Analysis* (2010)

as nets and boats. The fishing sector provides over 95,000 jobs[15], and makes up 4% of GDP and 28% of foreign exchange earnings[16]. Developing the country's hydropower potential of 13,000MW and effectively operating existing and future dams, such as Cahora Bassa and Mphanda Nkuwa, relies directly on an accurate record of hydrological data. Infrastructure such as bridges, roads, and drainage structures are improved by an accurate and long-term hydrological record. In transport, the efficiency and security of Mozambique's aviation industry is impeded by the absence of upper-air, lightning-detection, now-casting and higher spatial and temporal resolution forecasts[17]. Hydro-met information can enhance productivity of key sectors of the economy by providing information that can translate into economic output. Equally important, greater understanding of extreme weather events from more accurate, relevant and timely hydro-met information can minimise their negative impacts.

7. The Government's core responsibility for hydro-met monitoring and forecasting resides with a number of agencies across two ministries. The mandate for hydrology lies with the National Directorate of Water (DNA, Direcção Nacional de Águas) and the five Regional Water Authorities (ARAs, Administrações Regionais de Águas), which are both part of the Ministry of Public Works and Housing (MOPH, Ministério das Obras Públicas e Habitação). The mandate for meteorology is with the National Institute for Meteorology (INAM, Instituto Nacional de Meteorologia) located in the Ministry for Transport and Communication (MTC, Ministério dos Transportes e Comunicações)[18]. Noteworthy, there are other government agencies who manage climatological monitoring stations which feed into the national aggregate network for observation (such as the National Institute for Agrarian Research IIAM, Instituto de Investigação Agrária).

8. The role of hydro-met services that DNA, the ARAs and INAM provide is recognised in the Government's strategies, laws and policies. However, the efficacy of the services to fulfill their role has been undermined by a number of challenges. These include lack of financial sustainability, where government budget allocations, donor support and revenues are not commensurate with the service's estimated economic value and fluctuate significantly[19]; fragmentation of institutional responsibilities and weak interagency collaboration reflected in poor implementation of quality standards and calibration of monitoring stations as well as dissemination of raw data and advanced forecasts; and insufficient technical and staff capacity at multiple levels to operate and maintain monitoring and forecasting functions.

9. Nationally, these challenges result in only a small portion of the existing network of stations monitoring hydrology and meteorology being operational. The detailed evaluation of Mozambique's hydro-met services completed during project preparation revealed an inconsistent, disconnected and deeply weakened monitoring network. In terms of INAM's network for meteorological monitoring, for example, only 38 of 154 manned meteorological stations are reporting regularly (i.e., 25%), automatic weather stations increased from 3 to 12

[15] USAID http://www.speed-program.com/library/resources/documents/mozambique_fisheries_report_final.pdf (2011)
[16] FAO http://www.fao.org/fishery/countrysector/naso_mozambique/en (2003)
[17] The country's two Doppler Radars in Beira and Xai-Xai need rehabilitation and there is no lightning-detection system or upper-air monitoring. However, Mozambique's meteorological services are seeking to improve its services so as to secure the ISO 9001 certification of quality standards as a means to strengthen its engagement with the aviation sector.
[18] See section III.B for more details on hydro-met institutions.
[19] For example, despite that overall national budget resources have increased to INAM with an average of 8%/yr, the overall budget drastically decreased since 2009 due to a reduction in international donor support.

between 2005 and 2011 but remain low in comparison to needs, and the country's two Doppler Radars, which provide the only upper air monitoring, are not operating. In terms of the ARA's network of monitoring, the diagnostic showed that the ARAs manage a larger network than INAM (which includes monitoring of rainfall and evaporation otherwise monitored by INAM), yet the proportion of ARA's monitoring network that is operational and providing data is similar. For example, 218 of 592 stations monitoring river stage (i.e., 36%) and 329 of 1,318 of stations monitoring rainfall (i.e., 25%) are providing data[20]. The latter excludes the ARA's automatic stations, where only 3 of 8 are reported as operating. Overall, this means that roughly only a third of the collective hydro-met monitoring network is functioning and that there are substantial needs for rehabilitation, calibration and upgrade within the existing network.

10. INAM, DNA and the ARAs are maintaining daily forecasting functions. Predictions of incoming water and weather conditions are primarily communicated in the format of bulletins (produced centrally at headquarters in Maputo) and disseminated using email and fax as communication channels to reach a set list of recipients and agencies. In times of high river flows or severe weather events, the agencies provide monitoring and forecasting information three times per day according to the protocol managed by the National Institute for Disaster Management (INGC, Instituto Nacional de Gestão de Calamidades). Overall, these existing hydro-met products fail to meet the needs of users because of three major challenges: i) the lead time of forecasts is not long enough to allow time for appropriate decision making and action; ii) the space-resolution of forecasts is too low for location-specific information; and iii) the content, format and delivery of the forecasts are not tailored for key users.

11. The technical skills and levels of education of staff in INAM, DNA and the ARAs are significant and often match the technical needs of maintaining modern hydro-met services. However, the evaluation done during project preparation pointed to several challenges in human resources: the number of qualified staff is insufficient, the agencies have difficulty in retaining personnel, and several key staff members are tasked with responsibilities outside their immediate expertise. It is noticeable that, of all staff working with the five ARAs, 75% work in ARA-Sul, while the remaining 25% work across the other four ARAs.

C. Higher Level Objectives to which the Project Contributes

12. The proposed Project to transform Mozambique's hydro-met services will contribute to strategic objective of preventing and adapting to climate change in the Government of Mozambique's strategy for growth and development - the Poverty Reduction Action Plans (PARP – Plano de Acção para a Redução da Pobreza). Equally, the proposed Project supports the implementation of the 2012 National Strategy for Climate Change, the 2001 Water Policy, the 2007 National Water Resources Management Strategy of 2007 (ENGRH, Estratégia Nacional de Gestão de Recursos Hídricos), the 2013-2018 Strategic Plan for Meteorological Services, and the 2007 National Adaptation Programme of Action (NAPA).

13. The proposed Project will also contribute to the World Bank's Strategy for Africa[21] and its Country Partnership Strategy for Mozambique[22] (CPS, 2012-2015) by building resilience and

[20] The diagnostic of ARAs stations showed that some stations that were not reporting were closed in the early 1970s as they did not serve an integrated watershed management purpose.
[21] Africa's Future and the World Bank's Support to It (February 2011)
[22] World Bank *Mozambique Country Partnership Strategy* (2012)

adaptation to the negative effects of climate change and reducing the risk of natural disasters (CPS, Pillar II: Vulnerability and Resilience). In addition, the Project will build on the World Bank Country Water Resources Assistance Strategy (CWRAS, 2009) in enhancing hydrological and meteorological data for the core operation of water resources planning, infrastructure development and transboundary cooperation with neighbouring countries[23]. The proposed Project is furthermore closely aligned with the objectives of the National Water Resources Development Project (P107350, US$70 million IDA), which, among other objectives, will enhance the planning, management and development of national water resources. The proposed Project to strengthen hydro-meteorological information will contribute to the success of the IDA operation.

14. The Climate Investment Funds (CIFs) were set up to promote low-emission and climate-resilient growth[24]. In 2008, the Pilot Program for Climate Resilience (PPCR)[25] was approved as one of the CIF's strategic funds to finance the integration of resilience measures into core development planning. In June 2011, a Strategic Program for Climate Resilience[26] (SPCR) for Mozambique was created in support of this objective. The SPCR includes a combination of pilot investments in different sectors, knowledge management, and policy and institutional reforms. The SPCR identified the strengthening of hydro-meteorological services as a national priority in order to improve early warning systems for floods, droughts and storms; and to improve access to water and weather-related information. Subsequent to the SPCR, Mozambique's Council of Ministers endorsed a National Strategy for Climate Change in which the need to strengthen hydro-meteorological services was also identified as a key national priority. For these reasons, PPCR-funding has been allocated to the proposed Project as one of the SPCR pilots and is integrated into the aforementioned strategy. The project will contribute to the following SPCR objectives: strengthen the evidence-base for climate resilience in policy-making and planning; develop models and experience for building climate resilience; and strengthen capacity for climate resilient planning at national, sector and local levels.

15. A Mozambique Climate Change Development Policy Operation (DPO, US$150 million) was approved January 2013 to support implementation of institutional and policy reforms and contains two hydro-met policy actions. The policy actions will help the Ministry of Transportation and Communication and the Ministry for Public Works and Housing put in place reforms that can enhance the effectiveness of hydro-met services and build national climate resilience (see Annex 1). A companion Technical Assistance Project implemented in conjunction with the DPO will also strengthen knowledge management work and help transfer lessons learned from the pilots.

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[23] World Bank *Mozambique Country Water Resources Assistance Strategy* (2007)
[24] The CIFs channel funds through the Multilateral Development Banks, including the World Bank.
[25] http://www.climateinvestmentfunds.org/cif/ppcr
[26] PPCR *Mozambique - Strategic Program for Climate Resilience* (2011)

II. PROJECT DEVELOPMENT OBJECTIVES

A. Project Development Objectives

16. The Project Development Objective (PDO) is to strengthen hydrological and meteorological information services to deliver reliable and timely climate information to local communities and to support economic development.

17. The PDO will be achieved by investments in optimised hydro-met monitoring networks, more effective management and exchange of hydro-met data; and improving the capacity to forecast future water and weather conditions. As a result, transformed hydro-met services will support more robust early warning systems and relevant, accurate and timely hydro-met information. To achieve and sustain the PDO, the proposed Project includes resources for training and skills-development of staff and institutional strengthening.

B. Project Beneficiaries

18. The direct project beneficiaries are the government institutions mandated to monitor and forecast hydrology and meteorology. These are: the National Institute for Meteorology (INAM), the National Directorate for Water (DNA) and the five Regional Water Authorities (ARAs). Ultimately, improved hydro-met services will be advantageous for Mozambique's general public and economy; thus, the targeted beneficiaries are those people who are at risk from weather- and water-related disasters and those whose productivity could increase from higher quality hydro-met information.

19. A gender dimension exists among beneficiaries of improved hydro-met information – in part because Mozambique is experiencing an increasing feminisation of both vulnerability and small-scale farming[27]. Analysis of the social impact from climate change conducted in Mozambique emphasises that, for example, that women and girls will be more affected in drought-prone areas because of the increase of time spent in water collection activities. Successful delivery of hydro-met information that can support and improve decision making – before an impending flood for example – need to be tailored to the needs of the users and beneficiaries of the information. As such, project interventions will have to give due attention the needs of recipients in order to achieve successful results in building resilience and supporting productivity (i.e., gender, location, age and so forth).

20. Because the proposed *Climate Resilience: Transforming Hydro-Meteorological Services Project* (funded by the PPCR) is closely aligned with the IDA financed *National Water Resources Development Project* (IDA, P107350, NWRDP), the results from strengthening the hydro-met services will strengthen the operational foundation for management of water resources across the country. Additional government agencies will benefit from the use, dissemination and generation of hydro-met information themselves. These agencies include: the National Institute for Disaster Management (INGC, Instituto Nacional de Gestão de Calamidades), the Ministry of Agriculture (MINAG) and its National Institute for Agrarian Research (IIAM, Instituto de Investigação Agrária)[28], the National Maritime Authority

[27] In Chibuto District southern Mozambique, for example, male migration results in women representing 57% of total population. Africa Climate Change Resilience Alliance *Understanding adaptive capacity at the local level in Mozambique* (2012).

[28] The IIAM operate and maintain a number of agro-climatological stations across Mozambique, centrally collect the data and share with INAM. The strategic review of upgrading stations will include those of IIAM.

(INAMAR, Instituto Nacional da Marinha), the National Institute for Hydrography and Navigation (INAHINA, Instituto Nacional de Hidrografia e Navegação), and the National Institute for Civil Aviation (IACM, Instituto da Aviação Civil de Moçambique). The management and daily operation of water infrastructures for purposes including hydropower, irrigation and water supply can also benefit. Relevant agencies include: the ARAs, the Water Supply Investment and Assets Fund (FIPAG, Fundo de Investimento e Património do Abastecimento de Água), the Cahora Bassa Hydropower Company (HCB, Hidroeléctrica de Cahora Bassa) and the Mozambique Electricity Company (EDM, Electricidade de Moçambique), among others. The private sector interests would also benefit from access to better hydro-met data, including enterprises such as farming for commercial purposes, maritime transport and extractive industries, and aviation.

21. The media represents both a beneficiary agency as well as an important intermediary for dissemination of forecasts and warnings. The main government-run agencies that will transmit improved hydro-met information are: the National News Agency (AIM – Agência de Informação de Moçambique), Rádio Moçambique, and over 70 local community radio stations, the newspaper Notícias, and Television of Mozambique (TVM – Televisão de Moçambique). Privately run media agencies include Socio TV and TV Miramar, and Radio Miramar and Radio FM99. Although TV is seen mostly in cities and towns, it is national and local community radio that has the broadest reach and coverage[29]. As part of the expanding infrastructure for information and communication technology (ICT) in Mozambique, the GSM/GPRF network is growing rapidly and far into rural areas. This presents opportunities for the project in enhancing data and information collection and sharing as well as dissemination of forecasts and warnings.

C. PDO-Level Results Indicators

22. The results indicators at PDO-level are:

- 50% improved accuracy of hydrological and meteorological forecasts
- 50% longer lead-time of severe hydrological and meteorological forecasts in early warning systems
- 70% increased satisfaction of surveyed users among media, dam operators, aviation, and farmers

23. PPCR Indicators & Development Policy Operations Indicators:

- Changes in budget allocations at national & possibly sub-national level of government to take into account effects of CV & CC (PPCR Indicator)
- Evidence of strengthened government capacity and coordination mechanism to mainstream climate resilience (PPCR Core Indicator)
- Inter-ministerial Protocol on data sharing approved & implemented (DPO Policy Action)

[29]BBC http://www.bbc.co.uk/news/world-africa-13890419 (2012).

III. PROJECT DESCRIPTION

A. Project Components

24. The Project has three components. The first and second components will strengthen hydrological and meteorological information services respectively, and the third will pilot the effective exchange and delivery of hydro-met information services to specific user-groups ('end-to-end'). The proposed components and activities are closely associated and mutually reinforcing with the ongoing IDA-financed National Water Resources Development Project (P107350, NWRDP) and the two policy actions under the PPCR-supported DPO for Climate Change.

25. **Component A: Strengthening Hydrological Information Management** (total: US$10.30m, including US$1.00 m in-kind contribution from the GoM, US$8.8m from the PPCR and US$0.5m from the NWRDP). Component A will focus on improving hydrological information services by modernising monitoring and forecasting of water conditions, as well as developing the content and delivery of hydrological information products. The component will support: A1) Institutional strengthening and training program involving carrying out a training plan, staffing assessment, and capacity building activities for hydrological information management for the implementing agencies; A2) Enforcement of quality control and standards through developing modernised protocols, operating guidelines, and information management framework for collection, processing, and monitoring of hydrological data; A3) Optimising and reinforcing the physical hydrological monitoring networks through carrying out a detailed study and civil works to improve and optimise physical hydrological monitoring networks, including rehabilitation, upgrading, and standardisation of stations; A4) Transmission, accessibility and management of data supported by ICT through designing and implementing an integrated hydro-met information management platform; A5) Improving hydrological modeling, forecasting and flood/early warning systems of DNA and ARAs; and, A6) Developing and improving access to hydrological information products. These activities will be supported through the provision of: i) consultants services and technical assistance; ii) goods, equipment and non-consulting services, including hydro-meteorological and water quality monitoring equipment, mapping and digital elevation models, computers, vehicles and office equipment; iii) works to establish monitoring stations; and iv) training and capacity building.

26. **Component B: Strengthening Weather and Climate Information Management** (total: US$11.15m, including US$0.50m in-kind contribution from the GoM, approximately US$6.0m from the NDF[30], US$0.45m from the GFDRR[31] and US$4.20m from the PPCR). Component B will focus on improving meteorological information services by modernising monitoring and forecasting of weather conditions, as well as developing the content and delivery of meteorological information products. The emphasis of Component B is to consolidate and focus the existing meteorological services as a way to secure the foundation for the weather-information value chain; whilst in parallel build long-term sustainability and introduce opportunities for modernisation. The component will support: B1) Institutional strengthening aligned with the INAM Strategic Plan 2013-2018; B2) Organisational development and training; B3) Upgrading and implementation of a Quality Management System (QMS) for INAM; B4) Optimising the physical meteorological monitoring networks through rehabilitation of existing

[30] The NDF will focus support to activities C1-3.
[31] Global Facility for Disaster Reconstruction and Recovery

stations and installation of new ones; B5) Transmission, management and accessibility of data supported by ICT through upgrading INAM's existing data management system; B6) Strengthening meteorological modeling, forecasting and prediction of extreme weather/ early warning systems of INAM; and B7) Developing and improving access to meteorological information products. These activities will be supported through the provision of: i) consultants services and technical assistance; ii) goods, equipment and non-consulting services, including hydro-meteorological monitoring equipment, computers and software, vehicles and office equipment; iii) works to establish monitoring stations; and iv) training and capacity building.

27. **Component C: Piloting resilience through delivery of improved weather and water information** (total: US$2.00m, of which US$2.00m from the PPCR). Component C will pilot more effective delivery of hydro-meteorological information to key users. Overall, the pilots will test solutions to improve the exchange and delivery of tailored hydro-met information, will be scaled to the available resources, and will capitalise on the opportunities offered by partnering with other public or private agencies. The component will support four pilot activities: C1) Delivering early warning along the Zambezi, Limpopo and Incomati River basin by designing, implementing and evaluating the dissemination of accurate weather forecasts to communities; C2) Disseminating weather and water forecasts to farmers in Gaza and Inhambane Provinces by designing, implementing and evaluating the dissemination of accurate weather forecasts to communities; C3) Enhancing access to weather information for ports, commercial maritime and artisanal fishery communities in the coastal areas of Inhambane; and C4) Designing, implementing and evaluating innovative ideas for enhancing hydro-met services. These activities will be supported through the provision of: i) consultants services and technical assistance; ii) goods, equipment and non-consulting services, including hydro-meteorological equipment, computers and software, vehicles and office equipment; iii) works to establish monitoring stations; iv) competitive innovative techniques; v) training and capacity building activities; and vi) community participation procedures.

B. Project Financing

28. **Financing instrument.** The proposed financing comes from a grant of US$15 million provided by the Pilot Program for Climate Resilience (PPCR) which is one of the strategic funds under the Climate Investment Funds also supported by the World Bank. The PPCR Sub-Committee approved the project US$15 million allocation on February 21, 2013. The Project will also be implemented with parallel financing from the Nordic Development Fund (NDF) to Mozambique in the order of €4.5 million (approximately US$6.0 million) which will finance meteorological services[32].

29. **Project Costs.** An overview of the project costs by component and their corresponding financing is presented in the draft financing table below.

[32] The NDF will enter into agreement with the Ministry of Finance through which the client agencies would request direct payments to contractors based on the NDF providing its no objection (similar to those of the Bank).

Table 1: Financing overview (US$ million)*

Program Component	GoM**	PPCR P131049	NDF Parallel fin.	IDA P107350***	GFDRR P124755***	**Total**
A. Hydrological	1.00	8.80	0.00	0.50		10.30
B. Meteorology	0.50	4.20	€4.50/~$6.00		0.45	11.15
C. Pilots - building resilience		2.00	0.00			2.00
Total Baseline Costs	1.50	15.00	€4.50/~$6.00	0.50	0.45	23.45
Price contingencies						
Total Program Contribution	1.50	15.00	~$6.00	0.50	0.45	23.45
Other						

*At the time of Appraisal 1Euro = US$1.34, and 1US$ = 30MZN

**DNA and ARAs contribution to hydro-met is estimated at US$0.20 m/year (x5yr) INAM contribution is estimated at US$0.50m for project duration.

***The proposed Project is closely interlinked with the National Water Resources Development Project (US$70 million total). The GFDRR provides a Grant for Mozambique for rehabilitation of Mozambique's two Doppler Radars.

C. Lessons Learned and Reflected in the Project Design

30. Project design has been informed by the detailed evaluation undertaken by the World Bank during preparation, by relevant lessons learnt from similar projects under the PPCR and GFDRR, and by assessments in Mozambique that have been part of preparation for regional hydro-met initiatives. An overriding lesson is that a comprehensive approach is required for success and sustainability of hydro-met services; an approach that invests in institutions as well as infrastructure.

31. **Building both near-future and longer-term adaptation capacity.** A recently-completed review of the World Bank's experience of supporting climate change adaptation[33] identified, among others, the needs to focus on adapting to both climate variability as well as longer-term climate change at the national level[34]. The review highlighted 'anticipatory adaptation', especially through integrated river basin management approaches and developing ways of assuring reliable financing for hydro-met services.

32. **Strengthen institutional capacity and robust implementation arrangements.** The mandate to monitor and forecast hydrology and meteorology in Mozambique is split between two ministries. Although this is not uncommon, it does call for additional efforts to ensure and maintain consistency and to facilitating sharing of data. A critical lesson learnt from similar projects is that collaborations between hydro-met agencies need institutional and technical mechanisms with senior level endorsement. As such, project implementation will be guided through a joint Hydro-Met Working Group. This group was established during preparation and has supported the design of activities. In addition, the Climate Change DPO contains two policy actions that will strengthen the policy framework for hydro-met services: i) establish a protocol on data sharing and responsibilities during extreme weather and water events, and ii) reinforce the legal framework for the mandate of the National Institute for Meteorology. In addition, project design reflects the lessons learned from management and planning in reform processes of hydro-met services emphasise the need for expertise in system design, procurement, and

[33] Independent Evaluation Group. World Bank IFC MIGA (2012). *Adapting to Climate Change: Assessing the World Bank Group Experience. Phase III*. Independent Evaluation Group. World Bank, IFC, MIGA.

[34] Independent Evaluation Group. World Bank IFC MIGA (2012). *Adapting to Climate Change: Assessing the World Bank Group Experience. Phase III*. Independent Evaluation Group. World Bank, IFC, MIGA.

deployment, as well as dedicated leadership for resolving roadblocks clearly defined system-level requirements[35].

33. **Fiduciary capacities to manage complex procurement.** The project will have several implementing agencies and will involve complex procurements ranging from varied monitoring equipment to long-term staff training. As such, it will be important to have strong procurement and financial management as part of project implementation. Under the NWRDP, a Project Administration and Monitoring Team (PAMT) has been established within DNA with both a Procurement Specialist and a Financial Management Specialist. Both are familiar with the Bank's operational and fiduciary policies and procedures. The implementing agencies - INAM, ARAs and DNA - have agreed to the PAMT managing the fiduciary aspects of the proposed PPCR project.

34. **Strengthen institutional, financial and technological sustainability.** The success of modernising hydro-met services through the introduction of modern technology, institutional and staff reform and large, complex design criteria is often undermined by a lack of financial and institutional sustainability. To this end, the lessons learned point to the value of collaborating closely and continuously with decision makers in Government on the benefits from the services, monitoring progress and its value, as well as maintaining end users as active partners in the hydro-met value-chain. Sustainability of the Project investments will be strengthened through prioritising institutional capacity (such as quality management systems and training), cost-effective budgeting for the maintenance and expansion of hydro-met services, and selecting technological solutions for monitoring and forecasting that are appropriate to the context of the institutions and of Mozambique. In the latter, the implementing agencies have experienced how highly advanced equipment has failed due to theft and damage, and inability to quickly acquire and install replacements. Such risks will be considered an extra criterion in the detailed design phase of the Project investments.

35. **Secure linkages to regional hydro-met initiatives.** Mozambique is active in global, regional and basin partnerships. As a member of the World Meteorological Organisation (WMO), the Southern African Development Community (SADC), the Meteorological Association of Southern Africa (MASA) and several river basin organisations (RBOs), Mozambique contributes to and benefits from international hydro-met initiatives. Past, ongoing and future projects from which lessons can be drawn include: SADC HYCOS, FEWSNET, SARCOF and a future SAMPRO among others[36]. One important lesson learnt from these international engagements is the importance of strong linkages to national level systems. As such, the proposed project will seek to improve access to and the integration of data and predictions that are generated outside of Mozambique (such as access to upstream flow data or

[35]The National Weather Service Modernization and Associated Restructuring: A Retrospective Assessment http://www.nap.edu/catalog.php?record_id=13216

[36] SADC HYCOS – the WMO Global Hydrological Cycle Observation System project involves strategically located monitoring equipment that automatically measures and transfers hydrological data through a EUMETSAT connection that is then logged on a password-protected website; FEWS NET – the Famine Early Warning Systems Network is a USAID-funded project to provide early warning and vulnerability information on emerging and evolving food security issues; the SADC Drought Monitoring Center (DMC) is one of the WMO emerging specialised centers in Gaborone; the DMC also manages the SARCOF – the Southern Africa Regional Climate Outlook Forums coordinates forecasting activities and offer training, technical analysis and preparedness seminars; and SAMPRO – the SADC Regional Meteorology Project is under preparation with the aim of building capacity, increasing readiness and increasing national collaboration among meteorological services.

remote sensing data), as well as to facilitate opportunities for training, sustained operations and maintenance (O&M) and calibration of sensors through international collaboration.

36. **Building synergies with associated projects.** The project is fully integrated with the NWRDP. In addition to the aforementioned DPO on climate change, a GFDRR grant of US$1.4 million (P124755) includes support for the rehabilitation of Doppler Radars. Some project activities, such as piloting better application of hydro-met information for early warning systems (EWS) for communities vulnerable to flooding (Component C.1), can build on existing initiatives that reach the same user-groups. Lessons can also be transferred from the Bank's support to hydro-met services at the national level in other countries, such as the IDA-supported Shire River Basin Management Project in neighbouring Malawi (P117617), as well as river basin-level initiatives such as the Zambezi River Basin Management Program (P143542). Amongst support from other donors, synergies can be found in projects such as the PPCR pilot project to enhance agricultural productivity in the Limpopo (African Development Bank); the UN's "Geo-information for Disaster Management in Mozambique", aimed at building monitoring capacity with respect to: (i) spatial data infrastructure, (ii) flood monitoring web service, and (iii) disaster response community trained and able to use tools and expertise; the GIZ support for basin-wide monographs through the Limpopo Watercourse Commission (LIMCOM); or the use of high-frequency radio communication and simulation activities of the INGC supported by the MSB and IRC – among others.

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

37. **Implementation arrangements for the Project are aligned to the national agencies responsible for hydro-met services: the DNA, the five ARAs and INAM.**

38. The DNA combines the responsibility for policy making, implementation, planning and management of water resources, as well as provision of water supply and sanitation services. The strategic activities undertaken by DNA are operationalised by the five Regional Water Authorities (ARAs). The ARAs are public institutions reporting to the MOPH tasked with the management of water resources. They receive guidance and technical support from the DNA, primarily through its Department of Water Resources (DRH, Departmento de Recursos Hídricos) who also have a monitoring role. The ARAs are tasked, among others, with hydrological monitoring and forecasting.

39. The National Institute for Meteorology (INAM, Instituto Nacional de Meteorologia), within the Ministry for Transport and Communication (MTC, Ministério dos Transportes e Comunicações), is mandated to generate and coordinate the national meteorological services in all of Mozambique's ten provinces and 128 districts.

40. Overall, the Project Coordinator for the Project will be the Deputy Director within INAM or as designated by the National Director. This role is aligned with the Coordinator for the NWRDP which is the Deputy Director of DNA. Within DNA, the Project Administration and Monitoring Team (PAMT) established under the NWRDP will continue its support function on administration and fiduciary management (financial management and procurement) to the new proposed Project. To coordinate the daily technical and planning aspects of the project, DNA and INAM will have designated Component Coordinators. For implementation of respective

component activities, Activity Focal Points (AFs) will be selected in INAM, DNA and the ARAs. Prior to project effectiveness, the details on roles and responsibilities, communication procedures and project management will be further elaborated.

41. For those activities where there are mutual benefits between the agencies (such as ensuring WMO standards or establishing data sharing platforms) the Component Coordinators and, as appropriate, the Activity Focal Points will come together through the Hydro-Met Working Group established through a mutual Memorandum of Understanding during 2012 and chaired by the head of the water resources department in DNA. On the request of the implementing agencies, the routines and purpose of the Working Group will be further formalised to ensure the necessary inter-agency coordination, adherence to roles and responsibilities, enforcement of quality standards across agencies, and to undertake shared activities such as training.

B. Results Monitoring and Evaluation (M&E)

42. The Component Coordinators in each respective agency will be responsible for the monitoring and evaluation (M&E) of the project. The M&E will be integrated into the existing frameworks used by respective agencies and in the PIM, the methodology for monitoring and reporting progress will be specified.

43. The M&E framework will especially build on the existing reporting procedures that have been set up by the PAMT as part of the NWRDP in DNA. This prevents duplication of efforts and provides a more consistent system for evaluating the progress of the project. The M&E Officer within the PAMT will provide support to development and integration of the framework and regular reporting. In addition, the results framework of the global PPCR (January 2013 Results Framework) includes indicators with core indicators that have been reviewed and included as appropriate in the Project's results framework (see Annex 2). A mid-term review will be held approximately 2.5 years after project effectiveness. The Bank and the implementing agencies will undertake an implementation completion report upon project closing.

C. Sustainability

44. **Financial sustainability.** The lack of sufficient operational funding is a challenge for hydro-met services in Mozambique. At present, there is no fixed budget to support the country's hydro-met services, and specific allocations within the agencies are negotiated among a number of competing demands. This can partly be explained by the fact that the services are spread across multiple agencies. They have different government budget allocations and different levels of international donor support. In 2010, for example, the government's contribution to budgets accounted for 10% of DNA's budget, 55% of ARA-Sul's, and 73% of INAM's. To build financial sustainability, the Project includes activities such as the introduction of a quality management system, adapting services to user needs (through surveys and tailored information products) and greater political endorsement (through, for example the recently approved INAM Strategic Plan for 2013 – 2017). The implementing agencies will explore how best government financial support that is decentralised to provincial governments for the purposes of hydro-met does not compromise the delivery of the agencies' work at local levels. An ongoing Economic Analysis of Mozambique's hydro-met services, is providing the implementing agencies with insights into the socio-economic value of their services, which in turn will inform the political dialogue on government support.

45. **Institutional sustainability.** Sustainability of hydro-met services relies highly on the level of professional capacity and retention of key staff. All agencies have seen both fluctuation and challenges in securing the number of necessary staff. For example, the total number of hydrological readers in ARA-Sul dropped from 436 to 213 from 2008 to 2011. Among the other ARAs, the number of readers has been stable, yet substantially lower in comparison (78 in ARA-Centro, 115 in ARA-Zambeze, 26 in ARA-Centro Norte, and 39 in ARA-Norte). Overall, the portion of staff with university training is low, on average below 10%. In INAM, trained meteorologists make up 17% of staff (a total of 40 meteorologists) and Observers make up 44% (a national total of 100)[37]. Securing an adequate number of staff at different professional levels will be necessary to maintain future hydro-met services. As a mitigation measure, the project has dedicated long-term and on-demand training incorporated as part of the Project and, where needed, a detailed staffing assessment.

46. **Physical sustainability of monitoring network.** The worldwide challenge of sustainability of hydro-met monitoring equipment/stations also applies to Mozambique. Due to multiple factors, the equipment stops providing data and begins to disintegrate. To build sustainability into the project's investment into monitoring networks, the project emphasises the preference of appropriate and optimised technologies, making best use of available resources and close supervision with robust operations and maintenance capacity. The implementing agencies are experienced with the challenges of inconsistent or inappropriate technologies and have further expressed preference for a flexible and adaptable approach. The risk of failure of monitoring networks will be mitigated further through implementing annual reviews of the stations. For example, should automatic/telemetric stations contain equipment that are valuable and thus at risk of theft, then guards may be hired to protect the station. Other remedies can include having sufficient back-up power-supply (e.g. long-life batteries) to ensure that stations are able to transfer data effectively should there be cuts in electricity to a station; and involving and empowering the local communities in understanding and managing the value of the infrastructure in their vicinity. ICT solutions to allow oversight of the monitoring networks, incorporated into the Quality Management System, can also enable staff to identify bottle-necks or failure at an earlier stage.

V. KEY RISKS AND MITIGATION MEASURES

A. Risk Ratings Summary Table (High, Moderate, Low)

Stakeholder Risk	M
Implementing Agency Risk	
- Capacity	M
- Governance	M
Project Risk	
- Design	L
- Social and Environmental	M
- Program and Donor	L
- Delivery Monitoring and Sustainability	H
- **Overall Implementation Risk**	**Moderate**

[37] Institutional data collected as part of preparation survey.

B. Overall Risk Rating Explanation

47. The project's overall risk is rated moderate due to the institutional fragmentation of the hydro-met services, as well as the risks inherent with monitoring networks that are complex in design, spread across wide geographic areas, and susceptible to damage and failure.

48. To mitigate the risk of unclear and disintegrated mandates, the associated policy actions of the Climate Change DPO will support the development and approval of a protocol on data sharing as well as a Decree on INAM's role to ensure quality of monitoring across agencies. Furthermore, the Project includes activities where all implementing agencies will benefit, a quality management that provides consistency in both hydrological and meteorological monitoring networks and on data sharing, and the establishment of the Hydro-Met Working Group where roles and responsibilities for project activities are clarified. The major risk elements are associated with the issues of sustainability (financial, institutional and with the physical investments). The comprehensive approach that is reflected in the Project activities has been chosen so as to deal with these multi-layered sustainability risks.

VI. APPRAISAL SUMMARY

A. Economic and Financial Analyses

49. To estimate the value of strengthening Mozambique's hydro-meteorological services, an economic analysis is being completed by assessing costs and benefits of the proposed project. The desired outcome of the benefit cost analysis (BCA) is to verify the economic justification for the project, guide the project's priorities and investments during implementation, position the value of Mozambique's hydro-met services in a wider sociopolitical context, and create a baseline against which progress can be compared.

50. **A Total Present Value of US$70.37 million was estimated from the BCA calculations over a 50 year timeline using the basic assumptions and a 3% rate of discount; and a Net Present Value of over US$391.17 million was estimated using the household benefits approach and US$17.10 million was estimated using the sectoral benefits approach.** For all calculations, real values were applied that do not factor in inflation or potential changes in exchange rates. A discount rate of 3% was applied as a lower discount rate will give more weight to the social benefits side (the sensitivity analysis was re-run with 10% but this did not substantively change results).

Table 2. Benefit Cost Results (all values 2011 USD)

	Present value total costs	Present value benefits to households	Present value benefits of statistical lives saved	Present value sector benefits of improved forecasts
Total Present Value	**70,366,055**	461,532,215	35,688,351	87,483,764
Net Present Value		391,166,161	-34,677,703	17,117,711
Benefit Cost Ratio		6.56	0.51	1.24
Discount rate 3%				

51. The Benefits Transfer Analysis (BTA) of the value for households of moderately improved forecast in Mozambique, using 2011 data and a population of 23 million, shows that the annual benefits of moderately improved forecasts and warning is approximately US$19 million. Adjustments for the context of Mozambique were made to a previous benefits transfer analysis

on value of significantly improved forecasts to households (willingness-to-pay, WTP)[38]. The BTA on the reduction of natural hazards impact derived an annual total national value of statistical lives saved (0.593 statistical lives per year) of US$1.45 million. Weather and water related disasters include both fatalities and economic impact. Between 1980 and 2011, a total of 101,837 fatalities were caused by hydro-meteorological events (EM-DAT). The BTA of variability of economic output attributable to weather variability and day-to-day impacts derived an annual total national sector value of improved forecasts of US$3.56 million. In Mozambique, economic sectors are assumed to be relatively more sensitive due to the lower levels of investment in hydro-met mitigation capital.

52. The costs associated with the proposed Project are a total of approximately US$20.7 million (including the Euro 4.5 million Grant from NDF, where the exchange rate affects the total of approximately US$20.7-23.45 million). The total investments are assumed to be portioned evenly across the project implementation period of three years (i.e., US$4.14 million/yr). During and beyond implementation, costs will be incurred for operation and maintenance (O&M) and repair at an assumed 10% of total project investment (i.e., US$2.07 million/yr) for the time period of the analysis.

53. The sensitivity analysis strongly suggests the need for better evaluation of parameters for project evaluation. A basic sensitivity analysis was done with respect to assumptions on the discount rate, potential improvements in forecast quality and ongoing support from the Government of Mozambique or other unidentified agencies. As shown in table 3, results are relatively insensitive to the discount rate and the same policy recommendation emerges whether using a 1%, 3% or 10% rate of discount although at 10% the BCR of the sectoral analysis falls below 1.0. If the improvements in forecasts are less than assumed in the BCA, a significant reduction in NPV is expected. Assuming only 20% rather than 50% of the improvement in forecasts in Mozambique are achieved, NPV of household benefits fall by roughly 70%. Finally, if there is no budget increase for the relevant agencies to support project operation and maintenance, the NPV estimates fall precipitously.

Table 3. Sensitivity Analysis – Benefit Cost Results (all values 2011 USD)

Sensitivity Analysis	Parameter Value	NPV Households	Benefit Cost Ratio Households	NPV Sectoral Analysis	Benefit Cost Ratio Sector Analysis
Baseline	-	391,166,161	6.56	17,117,711	1.24
Discount Rate	1.0%	608,611,150	7.20	35,823,369	1.37
Discount Rate	10.0%	134,579,262	4.73	-3,714,267	0.90
Percent improvement in forecast[1]	See Footnote 1	114,246,833	2.62	-48,495,110	0.31
Failure to support budget for long-term operation, maintenance, and repair[2]	See Footnote 2	64,102,743	4.28	-3,676,370	0.81

[1]Table "Value of adjustment for level of forecast improvement" set to 20% instead of 50% and Table x values for "Percent reducible with perfect forecasts" and "Percent of perfect forecasts achievable with project" each set to 5% instead of 10%.
[2] Assumes that there are no increases in annual operations maintenance and repair above and beyond the initial investment. Assumes that the benefits realised in the first three years then degrade proportionally over the following two years as the system returns to current (prep-project) status.

[38] Lazo and Chestnut (2002).

54. **Omissions, biases and uncertainties.** Few economic studies can consider all of the potential benefits and costs of a specific project, especially with respect to all of the potential secondary and tertiary effects. The benefits that can be achieved, but difficult to attribute to the project investments include: longer-term infrastructure planning such as dams and water resources, energy and transportation facilities, and critical uses of climate information to build resilience against climate extremes; in-country development of human capital, improved training and education, and improved management systems; contribution to global weather forecasting data to strengthen global forecasting models; and reduction of impact of natural hazards on economic development. Anecdotal evidence suggests that there currently is better weather forecast information available online than is being provided by the GoM. If the project cannot compete with or provide value-added above and beyond alternative weather information sources it is arguable that the value of the project diminishes.

B. Technical

55. The design of the project interventions to support DNA, the ARAs and INAM in delivering more accurate, timely and relevant hydro-met services is the result of a 14-month preparation period, broad stakeholder consultations in Mozambique and findings from relevant research. During this time, the Bank's team and the implementing agencies focused their efforts on a needs-based assessment to define the project development objective. This provided the guidance for determining the appropriate components and activities to achieve the PDO. In addition to the needs-based assessment, and to validate its findings, a detailed diagnostic and survey of existing hydro-met services across the country was done. Furthermore, the Bank's team and the implementing agencies have undertaken consecutive consultations within the three implementing agencies, through workshops and through the formation of the Hydro-Met Working Group (that also includes disaster management and agrarian research). Throughout, consultations have also been completed with end users such as civil aviation authorities, disaster management agencies, maritime agencies, tourism, national radio, donors and NGOs, among others.

56. The Bank team travelled within Mozambique to consult technical staff in the ARAs' headquarters and basin management offices and in INAM's monitoring stations at airports and district offices and to review sections of the existing observation network (including manual river gauges and weather stations, telemetric/automatic measuring stations, SADC HYCOS stations, synoptic stations and Doppler Radars). During field visits, the team consulted representatives from provincial and district authorities, dam operators, commercial companies and local disaster management INGC personnel. Given Mozambique's strategic geographic location, synergies were built into project design with regional hydro-met efforts such as initiatives under the Zambezi Watercourse Commission (ZAMCOM) and the Joint Technical Operational Committee, which enables cooperation between dam operators and hydro-met agencies across Zambia, Zimbabwe and Mozambique. The Bank's technical support included specialists in the fields of water resources management, meteorology, hydrology, climate change, disaster risk management and economics (in part with the support of the GFDRR Hydromet Team). Close collaboration with the Climate Change DPO process has also enabled the design of mutually reinforcing and aligned policy actions that will incentivise the institutional reforms necessary to build sustainability and clarify mandates on monitoring and forecasting technologies.

57. The project design was also informed by previous research and publications, ranging from detailed flood risk assessments of strategic river basins to the evaluations of the economic impacts of water- and weather-related disasters in Mozambique. Aligned to the Government of Mozambique's policy frameworks, the project supports realisation of the technical priorities listed in the 2007 National Water Resources Management Strategy (ENGRH, Estratégia Nacional de Gestão de Recursos Hídricos) and the recently approved INAM Strategic Plan (SP) for 2013-2017. The latter SP was drafted by INAM with the support of the Bank's specialist in meteorology, reviewed through stakeholder consultations in Maputo, and presented to and approved by the Government's Council of Ministers on December 04, 2012. The SP will allow INAM to proceed with institutional reform, organisational development, and optimised technical investments. As a result, INAM will strengthen its services to national users, contribute and benefit more actively as a representative to the World Meteorological Organisation (WMO), and align with the Global Framework for Climate Services that was endorsed by the WMO member states in November 2012.

58. The Project's three components reflect the needs of DNA, the ARAs and INAM to transform their hydro-met services in a comprehensive manner – including institutional reform, capacity building, rehabilitation of and investment into observation and forecasting, and serving their users with more relevant and accurate hydro-met information. Components A and B are aligned according to the unique institutional context of Mozambique, where hydrology and meteorology reside in different ministries. Within each component, the activities have been chosen to meet the specific needs of the respective agency and its area of expertise. This alignment adds flexibility and defines more clearly the roles and responsibilities, and opportunities to cooperate across agencies. Component C was designed to pilot how improved monitoring and forecasting can result in better decision-making and actions with tangible benefits. Through the pilots (focusing on communities vulnerable to flooding, alerts to fishers and forecasts for farmers) the much needed interagency collaboration and exchange of information will be enhanced.

C. Financial Management

59. The implementing agencies have agreed that the Project Administration and Management Team (PAMT) in DNA will manage the overall fiduciary tasks as they already have specialists in financial management, and the proposed set up creates more streamlined and integrated procedures. The PAMT was set up in 2012 and it is handling FM matters of the National Water Resources Development Project (NWRDP, P107350).

60. A Financial Management Assessment was carried out in accordance with the Financial Management Manual for World Bank-Financed Investment Operations issued by the Financial Management Sector Board on March 01, 2010. The objective of the assessment was to determine whether the implementing agency, the National Directorate of Water (DNA) at the Ministry of Public Works and Housing, has acceptable financial management arrangements, which will ensure that: (i) the funds are used only for the intended purposes in an efficient and economical way, (ii) accurate, reliable and timely periodic financial reports are prepared, and (iii) the agency assets are safeguarded. The first assessment was carried out as part of the preparation of the National Water Resources Development Project in May 2011, and this assessment was updated during the last supervision mission conducted in September 2012.

61. The overall conclusion of the Financial Management Assessment is that the project's financial management arrangements satisfy IDA's minimum requirements under OP/BP 10.02.

The project financial management arrangements have an overall residual risk rating of Moderate. The latest Financial Management supervision mission concludes that DNA has been working to ensure compliance with Financial Management requirements for the Bank-financed projects. A summary of the financial management assessment and financial management arrangements for the proposed project are described in the Annex 4.

D. Procurement

62. The implementing agencies have agreed that the PAMT will manage all procurement-related processes. The capacity of PAMT was reviewed during preparation and found to be adequate for managing the additional activities from the proposed project, as the PAMT is staffed with qualified personnel recruited to manage the NWRDP, including an experienced procurement specialist.

63. Procurement for the proposed operation will be carried out in accordance with the World Bank's "Guidelines: Procurement of Goods, Works and Non-consulting Services under IBRD Loans and IDA Credits and Grants by World Bank Borrowers" published by the World Bank in January 2011 ("Procurement Guidelines"), in the case of goods, works and non-consulting services; and "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits and Grants by World Bank Borrowers" published by the World Bank in January 2011 ("Consultant Guidelines") in the case of consultants' services, and the provisions stipulated in the Grant Agreement. Further, the "Guidelines on Preventing and Combating Fraud and Corruption in Projects Financed by IBRD Loans and IDA Credits and Grants", dated October 15, 2006, and revised in January 2011 will apply.

64. The procurement risk associated with the project is rated as 'Moderate'. The coordination between the PAMT and the beneficiary institutions will be critical in ensuring timely implementation of agreed activities. Corrective measures to address the challenges in implementation have been considered in the project design; measures include the need for each beneficiary to have designated Component Coordinators and Activity Focal Points.

65. The procurement plan for the project has been prepared under the coordination of DNA during Project Appraisal. It will be updated at least annually (or as required) to reflect project implementation needs.

E. Social and Environment (including Safeguards)

66. The physical interventions of the Project involves rehabilitation and installation of equipment used to monitor hydrology and meteorology. Because the interventions will involve civil work of existing stations and new sites for new monitoring equipment, the project triggers three of the Bank's operational safeguard policies. These are OP/BP 4.01 Environmental Assessment, OP/BP 4.04 Natural Habitats and OP/BP 4.12 Involuntary Resettlement. The project has been classified as Environmental Category B, and as such, the remedial actions are to apply abbreviated screening guidelines with defined actions to be taken should any negative impact be foreseen on humans, natural environment or land. The civil works associated with the project are minor and thus, potential impacts small in scale and limited to the sites of monitoring equipment and their near vicinity. Overall, impacts are foreseen to be readily manageable or mitigated by simple measures.

67. The monitoring stations that contain the predominantly small-scale equipment jointly create a network of data points for collecting data. The equipment ranges from simple rain and river gauges that are visited by staff frequently and monitored manually, to more advanced automatic measurements of different parameters (rainfall, temperature, humidity etc.) and that communicate via telemetric technology to central stations in the river basin management offices of the ARAs or the District/Provincial offices of INAM (GSM/GPRS or high-frequency radio). The top-of-the-line equipment is the Doppler Radars, of which Mozambique has installed two, one in Xai Xai in southern Mozambique and one outside the second largest city of Beira, in the central region.

68. Common for most hydrological and meteorological stations is the limited physical space they need and minor disturbance they cause to the environment and human beings. The average size of land area that is required for a station is $1m^2$ for simple, manually monitored gauges, to $4m^2$ for automatic monitoring stations. The collective networks of stations extend over vast areas, some stretched across the different branches of a river system and others positioned in strategic locations where exposure to water and weather is critical. Examples of location-specific requirements include where rivers enter the country, where certain water abstraction demands need to be secured, or where weather monitoring is optimal or vital for nearby activities (such as locating Doppler Radars on high ground, or forecasting weather at airports).

69. The locations of certain monitoring stations are thus critical to the type of information that is being sought. For water resources management, the hydrological record should ideally be over 30 years to enable return-flow estimates. Therefore, reinforcing existing stations is a priority. A limited number of new stations may, in some cases, require the construction of access roads/paths to strategic location to allow for installation, monitoring and maintenance and operation. These are typically dirt roads, at times with a cover of gravel, with limited civil works impact. Creation of any new access roads and installation of new stations would be done in accordance with the Environmental and Social Management Framework with a Resettlement Policy Framework. These instruments outline the necessary remedial actions with respect to environmental and social impacts, respectively. Negative impact on land used for other purposes would have to be minimised and compensated, and impact on protected areas avoided to the extent possible.

70. **Social.** The potential social impacts include refurbishments/rehabilitation of existing stations, acquisition of new land for installing stations, as well as land for accessing stations. The social risks would include situations where land is already in use, or where access needed to be established. To mitigate these risks, the implementing agencies will use abbreviated screening guidelines as well as the Resettlement Policy Framework (RPF). The ESMF and RPF articulate the necessary remedial actions for any identifiable impact and which policies and laws that apply for compensation and consultation procedures. The screening forms were developed, reviewed and cleared by the Bank during project preparation. During implementation, the exact and detailed design of the optimised hydro-met networks will consider the geographical location and impact of works at each station. It is unlikely that the project will require land acquisition, and instead could initially seek vacant land that is owned by the government. If it is determined that minor land acquisition is necessary, the RPF provides guidance on the preparation of an abbreviated resettlement action plan.

71. **Environment.** The potential environmental impacts include impacts on the immediate environment of new station sites or refurbishment of existing station sites, as well as any new

simple access roads/paths. Potential adverse impacts can include, for example, clearing and loss of vegetation/trees associated with gauge houses, cable houses or automatic weather stations, as well as potential pollution risks from dry-cell batteries (the most commonly used power supply system to operate hydrological and meteorological sensors in automated operations mode) and location-specific risk of erosion. The ESMF outlines the responsibilities of contractors and actions to mitigate negative impacts on the environment. Interventions in protected areas will be avoided to the extent possible.

72. During preparation, the ESMF, including basic screening forms, was developed, reviewed and cleared by the Bank. During implementation, the exact design of the optimised hydro-met networks will consider the geographical location of each station. The implementing agencies will update and develop the ESMF and screening procedure to match the implementation of the detailed interventions.

ANNEX 1: MOZAMBIQUE'S STRATEGIC PROGRAM FOR CLIMATE RESILIENCE (SPCR)

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services Project

1. The Project will be financed primarily with a US$15 million grant from the Pilot Program for Climate Resilience (PPCR) Trustfund. The PPCR is one of the Strategic Funds of the Climate Investment Funds (CIFs).

2. The CIFs are a pair of financing instruments which help developing countries pilot ways to transform their economies through low-emission and climate-resilient development, with scaled-up funding channeled through the Multilateral Development Banks. Of the two CIFs, the Strategic Climate Fund (approximately US$2.2 billion) focuses on supporting developing country efforts toward climate-resilient, low-carbon development and to provide lessons through learning-by-doing. As part of the Strategic Climate Fund, the PPCR allocates dedicated funding to pilot approaches to building climate resilience that offer prospects for transformational impacts. The PPCR works in nine pilot countries: Bangladesh, Bolivia, Cambodia, Mozambique, Nepal, Niger, Tajikistan, Yemen, Zambia, and two regional programs (Caribbean and South Pacific). The total PPCR fund in 2012 was US$1.2 billion[39].

Mozambique's Strategic Program for Climate Resilience (SPCR) was endorsed by the PPCR subcommittee in June 2011 and is designed to play a catalytic role in promoting climate-resilient growth strategies working through three pillars:

(a) Pillar 1: Institutional and Policy Reform: The SPCR recognises the need to strengthen cross-cutting and sectoral policy and institutional frameworks and 'mainstream' climate resilience throughout existing policies. To support this process, the Bank is providing technical assistance for Mozambique's National Strategy for Climate Change as well as a US$150 million Development Policy Operation (DPO) for relevant regulatory/institutional reform.

(b) Transformational investment pilots: the Government of Mozambique has identified 7 potential pilots to be delivered through World Bank, African Development Bank and International Finance Corporation (IFC) programmes. Of these projects, there are three pilot investments in the World Bank portfolio: (i) Transforming Hydro-meteorological Services, (ii) Climate Change and Coastal Cities, and (iii) Climate Resilient Rural Roads. Other pilots, to be delivered through AFDB and IFC programs, cover sustainable land and water management, climate-resilient agriculture, forests and peri-urban water supply.

(c) Program and Knowledge Management.

3. **Coordination of the Mozambique SPCR.** The Ministry for Coordination of Environmental Affairs (MICOA, Ministério para a Coordenação da Acção Ambiental) leads coordination of the SPCR with support from the Ministry of Planning and Development (MPD, Ministério da Planificação e Desenvolvimento). MICOA is responsible for coordinating work on climate change policy and territorial planning and is also the focal point for the United Nations

[39] http://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Mozambique_SPCR__Final_November_0.pdf

Framework Convention on Climate Change (UNFCC). MPD has responsibility for overall budget coordination and expenditure prioritisation. MPD's engagement with the SPCR relates to mainstreaming climate change into sector planning and budget allocation. Implementation responsibility of the SPCR pilot projects resides in line ministries.

4. **The Climate Change Development Policy Operation series includes hydro-met-related policy actions.** As part of the DPO, two policy actions will reinforce the institutional and regulatory context of hydro-meteorological services. The first operation of this series (DPO 1) was approved by the World Bank Board in January 2031; during the preparation period, the Bank has worked closely with the implementing agencies as well as the PPCR coordinating ministries on formulation and agreement on the proposed policy actions.

5. **The DPO prior action is approval by the Council of Ministers of the Strategic Plan of the National Institute of Meteorology (2013-2017).** The INAM Strategic Plan was approved by the Council of Ministers on December 04, 2012. Subsequently reform triggers for DPO2 and DPO3 will strengthen the inter-ministerial cooperation and institutional framework required to underpin effective hydro-meteorological services. Specifically, these will comprise:

- A protocol for the management and exchange of data is approved through a joint ministerial *diploma* of the Ministry of Transport and Communications and the Ministry of Public Works and Housing.
- Decree approved by the Council of Ministers that updates and clarifies INAM's mandate at the national, regional, provincial and district level in relation to data standards, modelling, forecasting and knowledge management of meteorology and climate change.
- Ministerial approval of the introduction of new or revised policies or regulations, to be identified during DPO2 preparation, that operationalise (i) improved last mile connectivity, (ii) strengthened early warning systems, and (iii) sustainable funding of hydro-meteorological service delivery.

ANNEX 2: RESULTS FRAMEWORK AND MONITORING

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services

Project Development Objective (PDO):

To strengthen hydrological and meteorological information services to deliver reliable and timely climate information to local communities and to support economic development.

Results Indicators	Core	Unit of Measure	Baseline (2012)	Cumulative Target Values**						Data Collection and reporting			
				2013	2014	2015	2016	2017	2018	Frequency	Data Source / Methodology	Responsibility for Data Collection	Description (indicator definition) [40]
PDO Indicator One: 50% improved accuracy of hydrological and meteorological forecasts	☐	%	n/a	0	20%	40%	50%	50%	50%	Semi-annually	Progress Reports	DNA/ARAs/ INAM	Assessed in calibration & data verification
PDO Indicator Two: 50% longer lead-time of severe hydrological and meteorological forecasts in early warning systems	☐	%	n/a	0	15%	30	50%	50%	50%	Semi-annually	Progress Reports	DNA/ARAs/ INAM/INGC	Lead time between forecasts & extreme event
PDO Indicator Three: 70% increased satisfaction of surveyed users among media, dam operators, aviation & farmers	☐	%	n/a	0	20%	50%	60%	70%	70%	Annual	Surveys after rainy season	DNA/ARAs/ INAM	Target groups defined in first survey
PDO Indicator Five: Changes in budget allocations at national & possibly sub-national level of government to take into account effects of CV & CC.	☐	%	n/a	0	10%	20%	30%	40%	40%	Annually	Annual Government Budget	DNA/INAM	PPCR Indicator (CV: Climate Variability, CC: Clim. Change)
PDO Indicator Six: Evidence of strengthened government capacity and coordination mechanism to mainstream climate resilience	☒	Effective	MoU Hydro-Met Work Group	n/a	n/a	Effective	Effective	Effective	Effective	Annually	Progress Reports	DNA/INAM	PPCR Core Indicator (interagency sharing of information)
PDO Indicator Seven: Inter-ministerial Protocol on data sharing approved & implemented	☐	Status	Non existent	n/a	Draft	Approved	Impl.	Impl.	Impl.	Annually	Protocol / Reports	DNA / INAM / INGC	DPO Policy Action
Intermediate Result (Component A): Strengthening Hydrological Information Management													
River gauge stations open and reporting	☐	%	37%	37%	45%	60%	70%	80%	85%	Semi-annually	Progress reports	DNA / ARAs	Resulting from upgrades

[40] Core-/Indicators from the Revised PPCR Results Framework (Jan 14, 2013) have, to the extent possible, been incorporated in the Project's results framework; as well as the Bank's core indicators.

Results Indicators	Core	Unit of Measure	Baseline (2012)	Cumulative Target Values**						Data Collection and reporting			
				2013	2014	2015	2016	2017	2018	Frequency	Data Source / Methodology	Responsibility for Data Collection	Description (indicator definition)
Intermediate Result (Component A): Strengthening Hydrological Information Management (cont.)													
Real-time hydrological data entered into database	☐	%	0	0	20%	50%	150%	300%	400%	Annually	Reports from IMS	DNA / ARAs	New technologies & faster reporting
Real-time hydrological monitoring stations reporting	☐	#	8	10	10	15	20	30	40	Annually	Reports from IMS	DNA / ARAs	Strategic real-time monitoring
DNA and ARAs staff trained	☐	#	0	20	30	30	50	50	70	Annually	Progress reports	DNA / ARAs	Training plan
Technical review and audits of ARAs monitoring network	☐	Un/Satisfactory	0	n/a	Review complete	Satisfact.	Satisfact.	Satisfact.	Satisfact.	Annually	Audits	DNA / ARAs	Audits and annual reviews of network
Cumulative cost-recovery of ARAs	☐	Costs/ Revenues	n/a	Costs/rev establ.	Fin. Reports consist.	0	0	0	0	Annually	Financial audits	DNA / ARAs	Financial sustainability
Intermediate Result (Component B): Strengthening Climate and Weather Information Management													
Synoptic weather stations open and reporting	☐	#	41	41	50	75	80	80	90	Semi-annually	Progress reports	INAM	Resulting from upgrades
Daily weather forecasts provided at downscaled regions	☐	#	3	3	5	10	30	40	50	Semi-annually	Progress reports	INAM	Resulting from upgrades
Real-time meteorological data entered into database	☐	%	0	0	20%	50%	150%	300%	400%	Annually	Reports from IMS	INAM	New technologies & faster reporting
Real-time monitoring stations reporting	☐	#	17	17	17	25	40	60	80	Annually	Reports from IMS	INAM	3 region forecasts to prov. & distr.
Increased climatology data entered into WMO's international system used in GCM/GFM	☐	%	0	10%	20%	30%	50%	50%	50%	Annually	Progress reports/WMO	INAM	Strengthen global engagement
Numerical Prediction Model functioning	☐	#	0	0	0	1	1	1	1	Annually	Progress reports	INAM	Quant. Prediction modelling
Technical review and audits of INAM's network	☐	Un/Satisfactory	n/a	n/a	Review complete	Satisfact.	Satisfact.	Satisfact.	Satisfact.	Annually	Progress reports	INAM	Audits and annual reviews of network
INAM Staff trained	☐	#	0	10	10	20	40	40	50	Annually	Progress reports	INAM	Training plan
INAM Decree on data standards, modelling & forecasting	☐	Status	n/a	n/a	Draft	Approved	Impl.	Impl.	Impl	Annually	Decree / Reports	INAM	DPO Policy Action
Ability for INAM to recover costs	☐	Costs/ Income	n/a	n/a	±0 establish.	±0	±0	±0	0	Annually	Financial audits	INAM	Financial sustainability

Results Indicators	Core	Unit of Measure	Baseline (2012)	Cumulative Target Values**						Data Collection and reporting			
				2013	2014	2015	2016	2017	2018	Frequency	Data Source / Methodology	Responsibility for Data Collection	Description (indicator definition)
Intermediate Result (Component C): Piloting resilience through delivery of improved weather and water information[41]													
Direct project beneficiaries (number)	☒	#	0	0	1500	2200	2500	5000	6000	Annually	Pilot Evaluation/ Progress Reports	Pilot team	To be further determined in pilot design
Direct female project beneficiaries (% of total direct project beneficiaries)[42]	☒	%	0	0	750 (50%)	1300 (60%)	1500 (60%)	3000 60%)	3600 (60%)	Annually	Pilot Evaluation/ Progress Reports	Pilot team	Tailored information from pilots
Number of people supported by the PPCR to cope with the effects of climate change.	☒	#	0	0	1500	2200	2500	5000	6000	Annually	Progress Reports	Hydro-Met Working Group	PPCR Core Indicator
Extent to which vulnerable households, communities, businesses and public sector use improved PPCR-supported tools, instruments, strategies, activities to respond to CV and CC.	☒	%	0	0	30%	40%	70%	70%	70%	Annually	Pilot Evaluation/ Progress Reports	Pilot teams	PPCR Core Indicator
Proportion of beneficiaries receiving early warnings in target pilot districts in vulnerable parts of the Zambezi, Limpopo & Incomati floodplains	☐	%	0	0	0	30%	40%	60%	80%	Annually	Pilot Evaluation/ Progress Reports	Pilot teams	Integration of warnings in INGC EWS
Proportion of farmers receiving daily weather forecast in target pilot districts in the Gaza and Inhambane Provinces (Limpopo)	☐	%	0	0	0	30%	60%	80%	80%	Annually	Pilot Evaluation/ Progress Reports	Pilot teams	Tailored weather and water information for productive use
Proportion of beneficiaries in coastal areas receiving weather forecast in Inhambane	☐	%	0	0	0	30%	50%	60%	80%	Annually	Pilot Evaluation/ Progress Reports	Pilot teams	Tailored weather and water information for productive use and warnings
Innovative Pilot successfully implemented	☐	Yes/No	n/a	n/a	n/a	n/a	Yes	Yes	Yes	Annually	Pilot Evaluation/ Progress Reports	Pilot teams	INAM, DNA and ARAs staff pilot own designed solution to improve services

[41] Monitoring of the success of disseminating hydro-met information to beneficiary will include, to the extent possible, disaggregated analysis of recipients (i.e., location, income, gender etc.)
[42] Direct project beneficiaries from this project are people benefitting from pilots.

ANNEX 3: DETAILED PROJECT DESCRIPTION

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services

1. The Project Development Objective (PDO) is to strengthen hydrological and meteorological information services to deliver reliable and timely climate information to local communities and to support economic development.

2. The PDO will be achieved by investments into optimised hydro-met monitoring networks, more effective data management and data exchange. This will advance forecasting capabilities, which will feed into more robust early warning systems and the development of relevant, accurate and timely hydro-met information products for users. To achieve and sustain the PDO, the Project will also focus resources on training and skills-development of staff and institutional strengthening and reform.

3. As one of the pilot projects in the Mozambique Strategic Program for Climate Resilience (SPCR), INAM and DNA will be responsible for the proposed Project under the guidance of the Ministry for Planning and Development (MPD) who is concurrently the PPCR Focal Point. Annex 4 outlines the details of the implementation arrangements of the proposed Project. During implementation, there will be active sharing of lessons learned and knowledge products. Because hydro-met services provide the analytical foundation for understanding climate patterns, the project has a natural role to play in providing the public, other government agencies, academic institutions, the media and the private sector, as well as global climate services, with data and information that can build climate resilience.

4. The project will be implemented in close alignment with the National Water Resources Development Project (NWRDP, P107305, IDA US$70 million) implemented by the DNA and ARAs, where the provision of consolidated and improved information on rainfall and runoff patters is the foundation for improved operation of water infrastructure and planning of water use (abstraction, allocation, navigation etc.). The Government of Mozambique contribution in in-kind, human resources and other running-costs, and investments as part of the approved central budget allocation for hydro-met activities. For DNA and the ARAs, this amounts to US$1.00 million over the project period, and US$0.50 million for INAM (total US$1.50 million contribution).

5. The project consists of the following three components:

6. **Component A. Strengthening Hydrological Information Management** (total: US$10.30m, including US$1.00m in-kind from the GoM, US$8.8m from the PPCR and US$0.5m from the NWRDP). The specific objective of Component A is to optimise the GoM's hydrological monitoring, forecasting and information products as an input into decision making that builds climate resilience, reduces the risks of natural disasters (floods in particular) and improves productivity.

7. The activities under the component reflect interventions at multiple levels of the hydrological information value chain; from the collection of raw data to production of relevant information products. Component A particularly focuses on revitalising and modernising monitoring as a

foundation for enabling modelling/forecasting and as such, mitigating the impacts of extremes[43]. In addition, the component seeks improvements in the transmission, accessibility and management of data as it moves through the hydrological information system. The emphasis of the support under Component A is to consolidate and focus the existing resources to produce important, high-accuracy data whilst in parallel building long-term institutional, staff and financial sustainability. Component A aims to support DNA and the ARAs so as to transform them into more effective and operational National Hydrological Services (NHS) as guided by the WMO Technical Regulations (WMO-No. 49).

8. Component A will be supported through the provision of: i) consultants services and technical assistance; ii) goods, equipment and non-consulting services, including hydro-meteorological/geological and water quality equipment, mapping and digital elevation models, computers, vehicles and office equipment; iii) works to establish monitoring stations; and iv) training and capacity building.

9. Component A consists of the following activities:

A.1) Institutional strengthening and training program. Building technical capacity is a necessity for DNA and the ARAs as they improve their hydrological information services through the Project. During the survey conducted during preparation, all ARAs and DNA identify staff capacity as the key priority investment. Skills are needed at all levels, from basic maintenance of manual river stations to processing complex data streams and operating flow forecasting models or early warning systems. At the outset, the project will undertake a *Staffing Assessment and Long-term Training Plan.* The Training plan will include and build on an assessment of existing skills and how those are applied in respective roles and responsibilities. The Training Plan will be integrated into the existing training department and will outline the necessary annually reoccurring training, peer-to-peer learning, on-demand and short-term training in technical areas such hydrological monitoring, maintenance of equipment, hydrological modelling and estimation of flood impacts (with the objective of enhancing quality standards and maintenance across the information chain). Options for training will include, for example, south-south cooperation opportunities and online learning courses as they contribute to the achievement of the PDO. As part of the training programme, Activity A1 will include support for an internship programme. The Staffing Assessment will outline the necessary staff/skills needed at different critical functional levels, and draw up solutions to meet staffing needs. Activity A1 will subsequently finance the implementation of the Training Plan over the project period and is expected to be updated annually based on emerging needs for institutional strengthening. The recipients of training could, in addition to staff of DNA and the ARAs, include staff from INAM, INGC, MINAG and other beneficiary agencies to the extent that they are relevant.

[43] In January 2013, the Limpopo and Incomati Rivers experienced extreme flooding resulting in inundation of the floodplain areas of Chokwé, the city of Xai-Xai and northern Maputo. With over 150,000 people displaced, foregone human and physical assets including road and agriculture infrastructure as well as ongoing humanitarian crisis, Component A will support DNA and ARAs in effectively accessing and analysing river flow data from neighbouring countries, estimate accurately potential impacts and relay information in disaster response. Additional support would also help ARAs in identifying hydrological locations for structural interventions and implementing remedies to mitigate and manage flood conditions.

A.2) Enforcement of quality control and standards. To improve the quality of the outputs from data analysis, modelling and forecasting, better standards and quality control measures need to be implemented. Activity A2 will build on DNA and the ARAs' existing manuals and routines to develop modernised *Standard Operating Procedures (SOP)*, *protocols and guidelines* for: operating and maintaining the hydrological monitoring network (i.e., calibration against benchmark checks, rating curves, cleaning of sedimentation and vegetation etc.) to meet WMO standards (in line with WMO Manual 168 guide to Hydrological Practices vol. I & II); roles and responsibilities for data collection, transmission, verification and storage/security; procedures for inter-agency data exchange; and other areas as needed. Endorsement of protocols/SOPs and guidelines at appropriate level of management and Government will be sought to secure adherence and implementation of these quality management tools. Equally, DNA would consider establishing a dedicated team within DRH to provide *operational guidance* to the ARAs. The development of protocols and guidelines will provide a foundation for achieving the relevant policy action agreed in the Climate Change DPO (see Annex 1). Activity A2 will also include an *Information Management Framework* that enables DNA and the ARAs to have oversight of the hydrological information system, which in turn enables a more integrated system and detects bottle-necks when quality thresholds are not met. The management framework will rely on clear mandates of different departments across the ARAs and DNA so that remedial actions can be assigned to the appropriate staff. The management framework will be designed and implemented in parallel with INAM's Quality Management System to ensure consistency in quality in areas where the agencies overlap.

A.3) Optimising and reinforcing the physical hydrological monitoring networks. To improve hydrological monitoring, a *detailed optimisation and design study* will be undertaken by DNA and the ARAs (with support from external experts) on how monitoring can meet agreed user needs and how the implementing agencies shall agree among priorities (the study will include a detailed survey of stations). In the process of defining and designing an optimised national network, the implementing agencies will consider strategic socio-economic priorities for improved hydrological information for the purpose of water resources management (such as population movements and agricultural production) and early warning functions (such as minimising vulnerability and exposure to extreme flooding events). With the financial resources available, the planning phase of physical investments will support DNA and ARAs with undertaking planning through a process of prioritisation and balancing of needs (this includes consideration of costs/appropriateness of equipment, strategic geographical locations, maintenance costs etc.).

Notable is that DNA and the ARAs undertake extensive monitoring of rainfall, and to some extent, evaporation, at stations previously managed by INAM. The study will build on the detailed diagnostic done during preparation and previous literature and will include an inventory of currently weak metadata describing the details of the observation stations. The latter should be easy to update for DNA and ARAs so that changes in infrastructure can be recorded and retroactive correction of historical data can be calibrated. The study will include a decision making process led by DNA and the ARAs, where the prioritisation and sequencing of improvements are made. In parallel,

preparations will start the *optimising and reinforcing of ARAs' physical monitoring networks*.

Activity A3 will finance investments needed for: part/rehabilitation of the monitoring network that is not functioning but is needed in an optimal network; purchase of monitoring equipment for water conditions such as flow and quality; improvements to station environments (such as river bank stabilisation, removal of vegetation and desilting); upgrading rating curves and reaffirming alert levels; and installation, supervision and O&M of new monitoring stations. These stations could include both manual river gauges and technically advanced monitoring equipment that provide quasi/real-time flow of data yet be appropriate for the Mozambican context and be technically consistent across the ARAs. The physical investments include minor civil works for the installation of *equipment, transport and civil works* (such as access dirt roads/paths or supporting structures). The specific geographical areas of the monitoring network to be improved will include areas at risk of flooding, strategic locations at border crossing, areas of high water abstractions or areas of pollution risks, among others.

Just as real-time data flow is a priority – in particular during impending extreme events such as floods - so is the expansion and connectivity of data collection platforms. On the expressed preference of the ARAs, the use of existing equipment that is currently in storage should be explored alongside new, cost-effective technologies. With installation of advanced monitoring equipment, the associated communication infrastructure will need to be secured. Automatic monitoring can solve the insufficient temporal delivery of data (frequency and accuracy), particularly for flood conditions, and can reduce the risks of hazards to readers (such as floods, snakes and crocodiles). Still, experience shows that the highly advanced equipment stops providing readings due to theft, damage from floods, breakdown in power supply or inability to provide replacement equipment as part of maintenance. The installation of the latter will require contingency planning such as hiring guards or securing and enforcing warranties. More importantly, its technological solution should match the context that DNA and the ARAs are working in. While the rainfall and evaporation observations stations of the ARAs are and will continue to be located based on hydrologic needs, the ARAs recognise INAM's authority on meteorological standards. To ensure regular calibration, operation and maintenance and review of the network, the activity will finance recurring costs (estimated at 10% over the lifetime of the project) for *long-term maintenance of the monitoring networks*. Annual network reviews and three-year reviews of network coverage and interpolation potential will help plan calibration, expansion and upgrades. Without a professional and certified calibration facility in Mozambique, any current/velocity measuring equipment will not be reliable and therefore ineffective. To ensure accessible, regular and systematic calibration, an in-country facility is needed, as well as greater access to calibration and reference equipment. Partnerships with regional *calibration services* will be explored.

A.4) Transmission, accessibility and management of data supported by ICT. At present, readers predominantly transmit hydrological data manually on paper to the ARA's Basin Management Units and headquarters. Activity A4 will *design and implement a plan to equip readers with mobile phones* through which readings can be transferred in real-time to data management staff in the ARAs and/or to a repository database platform. Issues related to environmental impact (i.e., need for ruggadised

equipment), linkages to a payment system, or other efforts to minimise replacement costs will be considered. The ARAs currently use excel spreadsheets and HYDATA/HYDSTRA-entry points to transmit data to DNA. The ARAs and DNA indicate that their preferred format for data exchange is either text files, Excel, HYDSTRA or in certain cases ArcView Temporal Analyst. The activity will support DNA in the *strengthening of data management systems (such as HYDSTRA or other easily adapted and cost-effective applications)*, and the *design and implementation of an Integrated Information Platform (IIP)*[44]. The hydro-met services are in need of a single data-sharing platform as the front-end of a national database to effectively produce relevant information products. As such, an IIP will be able to receive and relay multiple streams of data and be connected to a GIS platform, as well as to web interfaces. The effectiveness of the IPP will rest on connecting and centralizing the data streams and databases (both manual and automatic). A critical function of the IIP will be to include or connect to modelling and forecasting (see Activity A5) and provide an early warning function (with thresholds agreed in accordance with INGC). As such, linked to the IIP, the *early warning systems and functions* would be refined. The GFDRR Labs have supported INGC in the development of the Open Data for Resilience (OpenDRI – data for resilience) work plan as part of a global initiative. Through the application of the GeoNode, an online platform has been developed to host and visualise data collected or created during the UNDP-supported report on "The Impact of Climate Change on Disaster Risk in Mozambique". Building on these efforts, the IIP will draw on these data resources, and equally relay useful updates or contributions to the GeoNode. The IIP could produce hydrological annuals and river hydrographs accessible to the public through the web-portal. In addition, the IIP would facilitate GoM's engagement in transboundary data sharing under regional agreements such as the Joint Technical Operational Committee (JTOC) and ZAMCOM.

To enable the transmission of data and the success of IIP, Activity A4 will finance goods and civil works needed for *data management improvements.* These include: ICT infrastructure to improve connectivity (such as reliable and hazard-proof network internet/GPRS connections to manage high volumes and fast data flows; as well as servers, licenses and soft/hardware) between stations, RBUs, ARAs and DNA; necessary ICT equipment would include modems, routers, power supply and data collection systems; and tools to verify/clean noise in data records. *Data rescue, digitisation and integration* of non-electronic records currently underway at DNA will continue so as to be integrated into the core information management systems. All ICT improvements (from equipment to software) will need to be integrated into the existing ICT systems of DNA and the ARAs and recorded in the ICT inventory for protection and sustainability.

A.5) Hydrological modeling, forecasting and flood/early warning systems. To enhance DNA and the ARAs' modeling and forecasting capacity, the challenges of data quality and inconsistency across software (from MIKE to Waflex) need to be overcome. Activity A4 will finance the IIP, whereas Activity A5 will finance preferred *modelling,*

[44] The IHMIP, compared to the HYDSTRA, could allow for greater integration of different data sources, include access to remote satellite data, relay other data source in other government agencies and include GIS and alert function.

flow forecasting and GIS tools such easily accessible Digital Elevation Models (DEM, currently accessible for free from HydroSHEDS, USGS/WWF at 3 arc-second - about 90m resolution and also from USGS at 1km resolution through HYDRO1k). DNA and the ARAs have indicated that they would prefer DNA to roll out a directive on standardisation for modelling and flood forecasting. An IIP could also integrate, where suitable, the USGS Geospatial Stream Flow Model (GeoSFM) which covers all of Mozambique (provided free-of-charge through FEWSNET, operates within ArcView GIS) for basins not yet modeled in greater detail[45]. Terrain surveys could include methods such as LiDAR (or similar tools) mapping. Rainfall data is a critical input, especially in real-time, to any flood forecasting. At present INAM and the ARAs do not share their respective rainfall data. INAM also has a satellite connection to EUMETSAT which could provide critical input to quantitative precipitation forecasts of the ARAs. The DNA and ARAs access specific hydrological information from government departments and technical counterparts in neighbouring countries. These sources of data are critical for early detection of impending floods, for example. Sharing of information is facilitated by a number of transboundary agreements (see Annex8). Therefore, the activity will support DNA and ARAs in their ability to share data and predict floods through international collaborations. In order to better mitigate the impact of extreme hydrological events (such as droughts or floods that are reoccurring in southern and central Mozambique with significant human and physical losses), the activity will also support DNA and the ARAs in assessing appropriate physical measures and structural interventions.

A.6) Development and improved access to hydrological information products. Ultimately, hydrological information products have a socioeconomic value if their content, format and accessibility meet the need of the user or decision maker. As such, DNA will *survey the satisfaction of key users* of current information products at the onset of the project. Based on the findings of the survey, DNA and ARAs would engage technical experts to explore the *options for hydrological information products* to better meet identified needs. Activity A6 will *strengthen and develop new products and modes of communicating* hydrological information products (e.g., through websites, multi-media, media or beneficiary government agencies) and tailor them during the implementation of the project depending on the satisfaction of users (surveyed on an annual basis). Annual aggregate reporting on hydrological data will be developed so as presented on DNA and the ARAs' website and in abbreviated Annual Reports (including data such as metadata of stations, maps, graphs showing long-term trends and the previous 12 months, services provided, and catalogue of information products). To ensure effective communication of hydrological information products, the purpose (such as water planning or state of emergency) as well as recipients (such as languages, geographical location, and gender) will be considered.

10. **Component B. Strengthening Weather and Climate Information Management** (total: US$11.15m, including US$0.50m in-kind from the GoM, US$6.0m from the NDF, US$0.45m from the GFDRR and US$4.20m from the PPCR). The specific objective of Component B is to

[45] GeoSFM can be used only in relatively large river basins without significant influence of dams in the hydrological regime.

optimise the GoM's meteorological monitoring, forecasting and information products as inputs into improved decision making that builds climate resilience, reduces risks of natural disasters and improves productivity. As with Component A, the activities under Component B reflect interventions at multiple levels of the meteorological information value chain. However, the needs-assessment done during preparation showed that Component B will have to focus especially on institutional strengthening and organisational development (including staff training) alongside much-needed rehabilitation and modernisation of meteorological monitoring. Component B will invest in solutions for improving forecasts through enabling INAM to better download satellite-derived weather data from the EUMETSAT Data Collection Service and the Global and Regional WMO Centers. INAM would thus begin strengthening its position as the Government agency mandated to provide Mozambique with meteorological services, in accordance with global WMO standards and the approved INAM Strategic Plan (2013-2017). Component B will be financed in parallel with a grant from the Nordic Development Fund (NDF), which activities are indicated below. Component B will be supported through the provision of: i) consultants services and technical assistance; ii) goods, equipment and non-consulting services, including meteorological equipment, computers and software, vehicles and office equipment; iii) works to establish monitoring stations; and, iv) training and capacity building.

11. Component B consists of the following activities:

B.1) Institutional Strengthening of INAM. At the onset of the project, Activity B1 will initiate an *Institutional Assessment* to identify how the agency can become more effective in fulfilling its role as a meteorology and climate services provider (providing systematic observation and monitoring of meteorological parameters; provision of quality-assured historical and real-time hazard data; weather analysis and mapping; as well as forecasts of weather and their changing patterns). INAM's mission is "to provide necessary meteorological information to ensure sustainable development of the national economy and to mitigate negative impacts of weather related hazards on human well-being and natural environment, and to fulfil national responsibilities for international data sharing". The institutional assessment will outline remedial actions and reforms that INAM would do to achieve this goal and secure the implementation of the INAM Strategic Plan for 2013-2017 (approved by the Council of Ministers December 04, 2012). The institutional assessment will moreover include a detailed staffing plan to identify how best to build and retain technical capacity and a necessary cadre of observers and meteorologists in INAM. Informed by the institutional assessment, Activity B1 will finance *annual Action Plans* that translate the recommendations from the institutional assessment and the strategic goals of the SP into scheduled and delegated actions. Progress will be monitored in accordance with the Action Plan, which will be implemented with a realistic budget. An *INAM Business Plan* will be developed so as to bring INAM closer to its users and begin tailoring services to needs, and thereby expedite the transformation of INAM into a modern and sustainable agency. The Business Plan will also fulfill a management function for the INAM's senior staff in internal and external matters. Activity B1 will predominantly be supported by NDF through consultancies and technical assistance.

B.2) Organisational Development and Training Plan. Activity B2 will facilitate the *operationalisation of the Action Plans and the INAM Business Plan*. This could include

clarifications on roles and responsibilities of all staff and departments, strengthened management functions, internal surveys, mechanisms for encouraging quality performance, and other organisational changes. Activity B2 includes the design and implementation of a *Long-Term Training Plan,* integrated into INAM's Training Department, in order to ensure staff capacity can maintain modern meteorological functions. The training plan will be informed by the institutional assessment and detail the necessary annually reoccurring training, peer-to-peer learning, on-demand and short-term training in the field of meteorological monitoring and forecasting. Activity B2 will finance implementation of the Training Plan and build on training offered in the region (from the WMO's Global and Regional Forecasting Center for ex), online courses, as well as potential twinning arrangements and south-south cooperation. The recipient of trainings will primarily include staff in INAM. However, because ARAs and IIAM perform rainfall monitoring, and INGC rely on INAM for managing extreme events, parts of the training will be equally beneficial for other agencies. Coupled with training, Activity B2 will include support for an internship programme. To support INAM and its staff at all levels, training will be coupled with *Technical Assistance on the modernisation process*. Activity B2 will be predominantly supported by NDF through consultancies and technical assistance.

B.3) INAM Quality Management System. In accordance with best practice and recent certification requirements from the International Civil Aviation Organisation, a *Quality Management System (QMS)* will be designed and implemented by INAM. In 2008, a QMS had been drafted but was never implemented due to the lack of funding and the supporting reforms needed. However, with the SP and the proposed Project, the QMS will fulfill a vital function. By setting and monitoring standards at all levels, the QMS will function as a management tool and plan for achieving the quality requirements within meteorology. The design of the QMS will build on the previous draft QMS, the INAM Business Plan (Activity B2) and international experience, and will include the upgrading of *standard operating procedures (SOP) and protocols* on aspects such as: standards for data collection (equipment and routines, WMO standards etc.); upgrade to easy-use manuals for data collection and O&M; and assigning clear lines of responsibilities in delivering quality services. Enforcement of the protocol and manuals on data standards and on data sharing are particularly critical for INAM as they could greatly benefit from the surface observations done by ARAs, IIAM among others. The implementation of the protocols will need ministerial-level approval, which is reflected in the associated Policy Actions in the Climate Change DPO. INAM and DNA will need to coordinate the development and implementation of protocols and guidelines so as to avoid overlap, and ensure effective implementation across the agencies yet remain relevant to each agency's activities.

B.4) Optimising the physical meteorological monitoring networks. Activity B4 will finance the optimisation and reinforcement of INAM's network of weather monitoring stations and equipment. The technical analysis performed during preparation (Annex 8) outlines the challenges facing INAM, and the fact that less than a third of the network is operating, calls for creative solutions to strengthen the monitoring functions of INAM. The optimisation process of deciding where, how and when to invest is guided by the priorities outlined in the SP and translated into activities in the annual action plans. However, INAM will need to balance resources between critical rehabilitation needs and

investment of appropriate technologies. As with hydrological monitoring, INAM's data sources are limited by their low temporal and spatial resolution. As such, the overarching goal of improving monitoring will be to enable more real time data flows, and greater densities of monitoring in key areas (including expansion of Data Collection Platforms). The investments under Activity B4 will be allocated to improve the surface and upper air monitoring. This will involve rehabilitation of existing equipment and stations, as well as installation of new. The stations and soundings to be improved could include where optimal: manual and automatic synoptic weather stations (AWS); temperature-wind soundings/profilers, introducing lightning detection system; integration and long-term O&M of the Doppler Radars (to be rehabilitated under GFDRR P124755). To ensure accessible, regular and systematic calibration, an in-country facility is needed; greater access to calibration and reference equipment and partnership with regional *calibration services* (such as South African Weather Services) will be explored. Activity B3 will also finance construction of necessary *equipment, transport and civil works to rehabilitate old and install new stations* (such as access dirt roads or supporting structures).

B.5) Transmission, management and accessibility of data supported by ICT. Transmission of meteorological data is done either manually by readers via paper that is sent to INAM's district and provincial offices; automatic in a few synoptic stations; or via internet portals (such as at airports). Activity B5 will *design and implement a plan to equip readers with mobile phones* through which readings can be sent to staff in INAM's decentralised offices and headquarters in Maputo and/or directly to the repository database (also linked to the IIP). Issues related to environmental impact (i.e., need for ruggadised equipment), potential to link with distribution of salary, or other efforts to minimise replacement costs will be considered. This renewed flow of information will necessitate a change in routines or revision of normal procedures; particularly on the receiving end and for staff who manage readers. Because forecasts, from general to real-time forecasts, depend on multiple streams of data and analytical capacity to interpret the data, Activity B5 will support INAM in *upgrading current data management system* (which at present is CLICOM). By integrating different data streams, forecasting capacity will be strengthened and INAM will be able to fulfill its obligations to provide data to the WMO Global Observation System and Telecommunication System[46]. Furthermore, Activity B5 will correspond with Activity A4 to ensure the access/exchange of an agreed set of data for respective information systems (HYDSTRA and IIP at DNA). To enable the transmission of data for INAM, Activity B6 will finance *data management improvements* which includes: ICT infrastructure to improve connectivity (such as reliable and hazard proof network internet/ GPRS/ fiberoptic connections to manage high volumes and fast data flows; as well as servers, licenses and soft/hardware); necessary ICT equipment including modems, routers, power supply and data collection systems; and tools to verify/clean noise in data records. *Data rescue, digitisation and integration* of non-electronic records will be integrated into INAM's core information management systems. All ICT improvements (from equipment to software) will need to be integrated

[46] WMO GOS is a coordinated system of methods and facilities operated by the WMO country members to make meteorological observations at a global scale in support of all WMO programs.

into improved/modernised ICT systems of INAM and recorded in the ICT inventory for protection and sustainability.

B.6) Meteorological modeling, forecasting and prediction of extreme weather /early warning systems. INAM will also *implement numerical weather prediction models* operating on 24/7/365 basis as an input into an *upgraded early warning systems*, where the application of digital elevation models/GIS tools and modelling software for analysing data and forecasting impacts is included. Access to precipitation data from radars, satellites and AWS is important for Quantitative Precipitation Estimates (QPE). QPE in turn is an important input into water resources management, including hydrological models and flood forecasting measures. INAM has limited capacity in calibration and maintenance, which includes all theoretical and practical aspects of measurement. As the country is very large and many remote stations are accessible only via poor roads, accessing the stations to perform maintenance is difficult, especially without proper technicians and vehicles. To improve forecasts, INAM will also be supported with *accessing remote sensing/satellite data and forecasts* such as through EUMETSAT and WMO's Global and Regional Forecasting Centers.

B.7) Development of meteorological information products. INAM's meteorological services are linked to a long list of users – ranging from Radio Mozambique to the country's Aviation Authority, and from INGC to the general public. Meteorological forecasts have a socioeconomic value if their content, format and accessibility meet the needs of users and decision makers. As a means to better meet their needs, INAM will undertake a targeted and cost-effective *survey of user needs* at the onset of the project. Based on the findings of the survey, INAM will hire technical experts to design *improved meteorological information products* to meet identified needs. Activity B7 will *develop new products and modes of communicating* them (e.g., through websites, multi-media, public media or beneficiary government agencies) and tailor them during the implementation of the project depending on the satisfaction of users (surveyed on an annual basis). With the improved quality of data monitoring and forecasting, INAM should be able to provide better seasonal outlooks, daily forecasts, early warnings, SIGMETs (Significant Weather Information Reports). INAM gives warnings to the public via media and its Internet pages. INAM has been able to significantly improve its analyses and warning systems for cyclones, which has also been recognised by the Government. However, currently the observation network is very sparse and INAM does not have the capacity to reliably on-line data from observation stations or to produce weather forecasts with high spatial and time resolution. In particular, the lack of weather radar data affects forecasting of floods. INAM would ensure that all users receive timely information at all ranges available (very short, short, medium and long-range). For each time range, there should be specific outlook, watch, or warning to enable all users to have effective and efficient use of meteorological information. Color-coded information and pictograms will be developed further, as they have been proven as the most effective way of communicating warnings. To ensure effective communication of meteorological information products, the purpose (such as water planning or state of emergency) as well as recipients (such as languages, geographical location, and gender) will be considered.

12. **Component C. Piloting resilience through delivery of improved weather and water information** (total: US$2.00m, of which US$2.00m from the PPCR).

13. The objective of Component C is to extend the end-to-end transmission of hydro-met information in order to improve climate resilience, reduce risk to natural disasters and enhance productivity among hydro-met-informed sectors. However, the core mandate of the hydro-met agencies does not encompass the entire chain of information flow (and associated value of hydro-met services). Component C provides opportunities to pilot the delivery of hydro-meteorological information to key users in specific locations[47]. The design of the pilots will be further developed during implementation but will grow out of collaborations among a number of agencies and actors. The pilots will allow for innovative solutions, where trial and error will adjust the pilots over time and inform decisions regarding how well the pilots are reaching the beneficiaries (with consideration to gender and poverty) and how additional resources can be mobilised. Because the pilots will be scaled to available funding and appropriate technical solutions, and involve activities that are in cases beyond the political mandate of the core implementing agencies, the component will capitalise on partnerships between INAM, DNA and the ARAs on the one hand and other agencies such as INGC, MINAG, INAMAR; the media and mobile phone communication operators; the private sector and commercial agencies; and NGOs. Component C will be supported through the provision of: i) consultants services and technical assistance; ii) goods, equipment and non-consulting services, including hydro-meteorological equipment, computers and software, vehicles and office equipment; iii) works to establish monitoring stations; iv) competitive innovative techniques; and v) training and capacity building.

14. The pilot activities proposed under Component C are:

> **C.1) Delivering early flood warnings along the Zambezi, Limpopo and Incomati Rivers**. Mozambique has some of the region's most well-established institutional structures and procedures for managing disasters. DNA and INAM have permanent representation at INGC's technical committee, where information on current status and forecasts are discussed. During intense periods of the rainy season, the agencies send staff to INGC's response office to enable more effective exchange of forecasts and updates. At the Province and District level, formal and informal cooperation between INGC, DNA, the ARAs and related agencies is mobilised at times of crisis (based on the Prime Minister declaring a state of emergency). One of INGC's main constraints is the accuracy and timeliness of the data from INAM and DNA (derived from the ARAs, or directly from the ARAs to INGC at a decentralised level). This inhibits INGC in deploying resources and personnel with sufficient time and geographic specificity. At present, the standard format for communicating forecasts and status updates from INAM and DNA is the 'daily bulletin', which is faxed and emailed. During extreme conditions, information is communicated via high-frequency radio, and there are informal procedures among staff at national and local level to speed the response. When INGC determines to

[47] Because the beneficiaries of the pilots are communities that have little access to economic resources and mobility, and whose vulnerability is characterised by a greater exposure to the extremes of weather and water (i.e. floods and droughts), it will be particularly important to tailor the final information to the recipients. Whilst tailoring the hydro-met information to recipients, consideration to gender will be critical – reflecting the generational and gendered dimensions and needs of the beneficiary communities.

mobilise a response, a color code "red" is activated, and ultimately communities are alerted to move to higher ground. In Mozambique, the lower stretches of the Zambezi River (especially from the confluence with the lower Shire River and downstream including the districts of Mutarara and Caia at the confluence, and Marromeu, Mopeia and Chinde to the Delta) and the expansive and topographically flat floodplains of the Limpopo and Incomati River basins are notoriously affected by flooding (most recently in January in the latter areas). Communities live and farm along the floodplains and, at times, alerts on impending floods reach them very late. In other cases, areas such as Chokwe and Xai-Xai are more densely populated but with limited access to move once the floods hit and transport links are cut (such as the north-south highway EN1). Activity C1 will involve the *design, implementation and evaluation of a pilot* for alerting communities in target and flood-prone areas in support of INGC's existing routines and collaborations with national and local radios (in local languages). The objective of the pilot will be to make use of the ARAs and INAM's more accurate and earlier predictions, and through the chain of information flow, provide more tailored and location-specific alerts that reach a network of stakeholders (from affected communities to NGOs present in the area, from decision makers who deploy response to local officials). Equally, the pilot would include collaboration with key stakeholders that operate the major water infrastructures in the basin.

C.2) Disseminating weather and water forecasts to farmers in Gaza and Inhambane provinces (Limpopo). Of the total cultivated land in Mozambique, 97% is for subsistence agriculture (see Annex 10). Moreover, semi-commercial or commercial farming is limited to 4% of its potential despite available land and water resources. The actions of subsistence farmers, and especially more risk-taking farmers, is informed in part by the availability of water and preferable weather conditions. Hydro-meteorological information is commonly communicated via radio, TV or through the extension network of MINAG and IIAM (e.g., agro-met or seasonal bulletins). Some of the most intensive farming in Mozambique is along the Limpopo River in southern Mozambique. The basin is affected by upstream activities in Botswana, Zimbabwe and South Africa, as well as by reoccurring droughts and floods. Activity C2 will involve the *design, implementation and evaluation of a pilot* tailoring information about weather forecasts (seasonal, medium and short term) through local and national radio and other communication channels[48]. By establishing a more direct way of communicating with farmers, providing more relevant information about water flows/levels in the river system will be explored. The activity will be implemented in collaboration with MINAG and the national and local radio stations, and aligned with the activities under the parallel PPCR pilot to improve agricultural productivity in the Limpopo basin (supported by the African Development Bank).

C.3) Weather information in coastal areas of Inhambane. Mozambique does not have a robust marine observation network and INAM provides very limited products that may contribute to the safety of marine fisheries and transportation. There is considerable

[48] The pilot will be designed with consideration on synergies with a number of initiatives in the Limpopo such as IFAD's Adaptation for Smallholder Agriculture Programme (ASAP) and its project "Pro-poor value chain development project in the Maputo and Limpopo Corridors" and the DFID-Hadley Centre Climate Science Research Partnership (CSRP).

potential for specialised marine weather forecasts, and installation of buoys in key locations could improve INAM's marine forecasts, as will re-launch existing Doppler Radars. The lack of communication channels and equipment between INAM and coastal communities is of particular concern. Furthermore, to reduce the pressures on near-coast fish reserves, fishermen are increasingly moving further out to sea to fish. This brings growing risks and exposure to greater weather forces. At present, INAMAR publishes a daily bulletin with weather forecasts on its announcement board. Interested parties can meet at the office to retrieve updates on incoming weather. Artisanal fishery provides both livelihood and food security for communities along the coast of Mozambique. Among the more intensively fished areas, Inhambane is located in the south. When more extreme weather conditions arise, there are a number of challenges to disseminating alerts or adequate forecasts. Such events have safety implications, but also lead to loss and damage to equipment, including boats and nets. Activity C3 will *design, implement and evaluate* a pilot to provide alerts and marine information reaching fishers, people engaged in fish-markets and marine transport. The pilot will build on partnerships with INAM, INAMAR, the Institute for Development of Artisanal Fishery (IDPPE, Instituto de Desenvolvimento de Pesca de Pequeña Escala), the National Institute for Hydrography and Navigation (INAHINA) and other relevant stakeholders.

C.4) Innovations for improving hydro-met services. Staff in INAM, DNA and the ARAs request better solutions to enhance service delivery**.** Internally created, innovative solutions will be explored through this activity, with the focus on appropriate ICT solutions, such as combining seasonal forecasting from DNA, ARAs and INAM along with IIAM and others into more streamlined information products. Activity C4 will finance the *design, implementation and evaluation* of the selected pilots.

Table 4: Detailed financing estimates (US$ million)

Program Component	GoM	PPCR	GFDRR	IDA	NDF*	**Total**
A. Hydrological	**1.00**	**8.80**		**0.50**		**10.30**
A1. Institutional strengthening & training		1.60				1.60
A2. Enforcement of quality control & standards		0.30				0.30
A3. Physical hydrological monitoring networks		3.00				3.00
A4. Transmission and management of data		1.80				1.80
A5. Hydrological modeling, forecasting & Flood/EWS		1.20				1.20
A6. Hydrological information products		0.90				0.90
B. Meteorology	**0.50**	**4.20**	**0.45**		**6.00**	**11.15**
Technical Assistance (Long- and Short-term)					2.20	2.20
B1. Institutional strengthening					0.30	0.30
B2. Organisational Development & Training					0.15	0.15
B3. INAM Quality Management System					0.05	0.05
B4. Physical meteorological monitoring networks		1.60			2.85	4.45
B5. Transmission and data management		1.00			0.00	1.00
B6. Meteorological modeling, forecasting & extremes/EWS		0.90			0.25	1.15
B7. Meteorological information products		0.70			0.20	0.90
C. Building Resilience		**2.00**				**2.00**
C1. EWS in Zambezi, Limpopo and Incomati River basins		0.70				0.70
C2. Forecasts to farmers in Gaza and Inhambane provinces		0.60				0.60
C3. Coastal weather forecasts in Inhambane		0.40				0.40
C4. Innovations for improving hydro-met services		0.30				0.30
Total Baseline Costs	1.50	15.00	0.45	0.50	6.00	**23.45**
Total Program Contribution	1.50	15.00	0.45	0.50	6.00	23.45

Above investment estimates consider physical and price contingencies as well as O&M (ca 10%) in component A3-5, B4-6.

ANNEX 4: IMPLEMENTATION ARRANGEMENTS

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services Project

A. Institutions.

1. **The institutional responsibilities for the proposed Project are aligned with mandates designated by the Government for hydrology and meteorology which reside across two ministries:** First, in the Ministry of Public Works and Housing (MOPH, Ministério das Obras Públicas e Habitação), the National Directorate of Water (DNA, Direcção Nacional de Águas) and the five Regional Water Authorities (ARAs, Administrações Regionais de Águas) are responsible for water resources management.

2. The DNA combines the responsibility for policy making, implementation, planning and management of water resources, and of water supply and sanitation services. The strategic activities undertaken by DNA are operationalised by the five Regional Water Authorities (ARAs). The ARAs are public institutions reporting to the MOPH tasked with the management of water resources. They receive guidance and technical support from the DNA, primarily through its Department of Water Resources (DRH, Departmento de Recursos Hídricos) who also have a monitoring role. The ARAs are tasked, among others, with hydrological monitoring and forecasting.

3. ***The DNA will as implementing agency have the responsible for reporting and associated fiduciary requirements including financial management and procurement for the Project through the already established Project Administration and Monitoring Team (PAMT). Technical departments in DNA and the ARAs will be implementing entities responsible for the technical aspects and implementation of the project activities, related to hydrology - including strategic planning, implementation and supervision etc. DNA and ARAs will be responsible for delivery of Component A-Strengthening Hydrological Information Management, and designated activities under Component C – Piloting Resilience through Delivery of Improved Weather and Water Information.***

4. DNA and the ARAs are already supported by the World Bank through the National Water Resources Development Project that became effective March 2012 (NWRDP - IDA US$70 million, P107350). A number of activities under the NWRDP will be mutually reinforcing with the proposed Project, as the provision and reliability of hydrological data and rainfall data will enhance the infrastructure planning and allocation of water, among others. The PAMT was set up as part of the NWRDP.

5. Second, in the Ministry for Transport and Communication (MTC, Ministério dos Transportes e Comunicações), the National Institute for Meteorology (INAM, Instituto Nacional de Meteorologia) has the mandate to generate and coordinate the national weather services in all of Mozambique's ten provinces and 128 districts. As the national weather service provider, INAM collects meteorological data with a primary purpose to make predictions of future short-, medium- and long-term climate; especially with regards to impending extreme events such as cyclones. Compared to DNA and the ARAs, INAM interacts with a broader set of agencies in the public and private sectors that use meteorological forecasts for decision making. INAM collaborates with the World Bank as part of ongoing support from GFDRR (Global Facility for Disaster Reconstruction and Recovery) to rehabilitate the two Doppler Radars.

6. ***INAM will as implementing agency be responsible for technical aspects and implementation of the project activities related to Meteorology - including strategic planning, implementation and supervision etc. INAM will be responsible for the delivery of Component B – Strengthening Climate and Weather Information Management, and in collaboration with other agencies, the delivery of activities under Component C – Piloting Resilience through the Delivery of Improved Weather and Water Information.***

B. Project management structure and responsibilities.

7. **Director-level Management Committee functions.** The Management Committee will provide the function of strategic leadership, decision making, and budget approvals, and allow for senior level managers in INAM and DNA to come together for strategic guidance of the project. The chair will be the National Director for INAM or DNA, or their designated Deputy.

8. **Inter-agency Working Group on Hydro-Meteorology.** Director level management will be supported by a Hydro-Met Working Group who will discuss and prepare the issues for management review and approval. The Hydro-Met Working Group has already been established through a Memorandum of Understanding between DNA, ARAs, INAM as well as INGC and IIAM in July 2012, and is chaired by the Head of the Water Resources Department in DNA. Representatives from these agencies will come together in the working group to prepare annual work plans and collaborative activities, review progress, share information for reporting (such as M&E and fiduciary), and resolve any technical issues etc. During implementation, the functions of the Working Group will be formalised further to facilitate coordination of the various activities across the project and agencies, and become an operational mechanism to jointly manage the project. The Working Group will be chaired by an individual as chosen by the implementing agencies.

9. **Project Coordinator.** The project management and coordination responsibility will reside with the Project Coordinator within INAM with the required level of Deputy Director, also representing the official project management counterpart for the World Bank. Similarly to the NWRDP, its Project Coordinator is the Deputy Director for DNA.

15. **Component Coordinators and Activity Focal Points.** To manage the respective two main components A and B, Component Coordinators in DNA and in INAM will be selected to be responsible for managing, administrating and supervising the respective components and activities[49]. The Component Coordinators will also be active in leading the deliberations of the Hydro-Met Working Group[50]. To deliver the activities agreed under each components, Activity Focal Points will be designated who represent the technical expertise and responsibilities of the activities and geographic location of interventions. Activity Focal Points in DNA and the ARAs have already been designated as part of the NWRDP, and the same arrangements are proposed for the new Project.

10. For Component A, DNA has designated its Water Resources Department (DRH) to manage the component in conjunction with designated focal area points in DNA and the ARAs as

[49] Prior to project effectiveness, the roles and responsibilities of the Component Coordinators will be consolidated.

[50] Facilities for shared activities between the agencies will be explored on a demand basis. At decentralised level, strengthened cooperation will be facilitated whereby INAM staff can cooperated directly with ARAs staff at basin level or provincial/district level.

responsible for the activities. The Component Coordinator will dedicate approximately 60% of her/his time to the project, and the Activity Focal Points on average 40%.

A1. Institutional strengthening & training	*- All activities: Department of Water Resources & ARAs.*
A2. Enforcement of quality control & standards	
A3. Physical hydrological monitoring networks	
A4. Transmission and management of data	
A5. Hydrological modeling, forecasting & EWS	
A6. Hydrological information products	

11. For Component B, INAM has designated the following departments/staff in the institution as responsible for the activities under the component:

B1. Institutional strengthening	*- Component Coordinator*
B2. Organisational Development & Training	*- Training Department*
B3. INAM Quality Management System	*- QMS Management*
B4. Physical meteorological monitoring networks	*- Observation & Network Department*
B5. Transmission and data management	*- IT Department*
B6. Meteorological modeling, forecasting & EWS	*- Forecasting Department*
B7. Meteorological information products	*- Research Department*

12. **The Project Administration and Monitoring Team (PAMT) in DNA.** The PAMT supporting the implementation of the IDA operation NWRDP, currently consists of a Project Manager, Procurement Specialist, Procurement Officer, Financial Management Specialist, Monitoring & Evaluation Officer, Administrative Assistant and a Driver. The PAMT will incorporate the project management functions of the proposed Project for administration, reporting (progress, M&E), financial management and procurement functions. They will collaborate closely with the Component Coordinators and Activity Focal Points in various departments within DNA, in INAM and the ARAs on the technical delivery of the Project. For example, technical staff across the implementing entities will prepare the documentation for procurements whereas the PAMT will guide and manage the procurement processes (see section B below for more details).

13. **Technical Assistance.** To strengthen the implementing agencies' capacity to manage technical specifications, supervise and carry out review of the complex investments, the project includes Technical Assistance (TA) opportunities - both long-term and on demand. For example, under the Nordic Development Fund's support, dedicated TA resources have been agreed to help the transition in service levels as well as capacitate the staff of INAM.

C. The role of other government agencies.

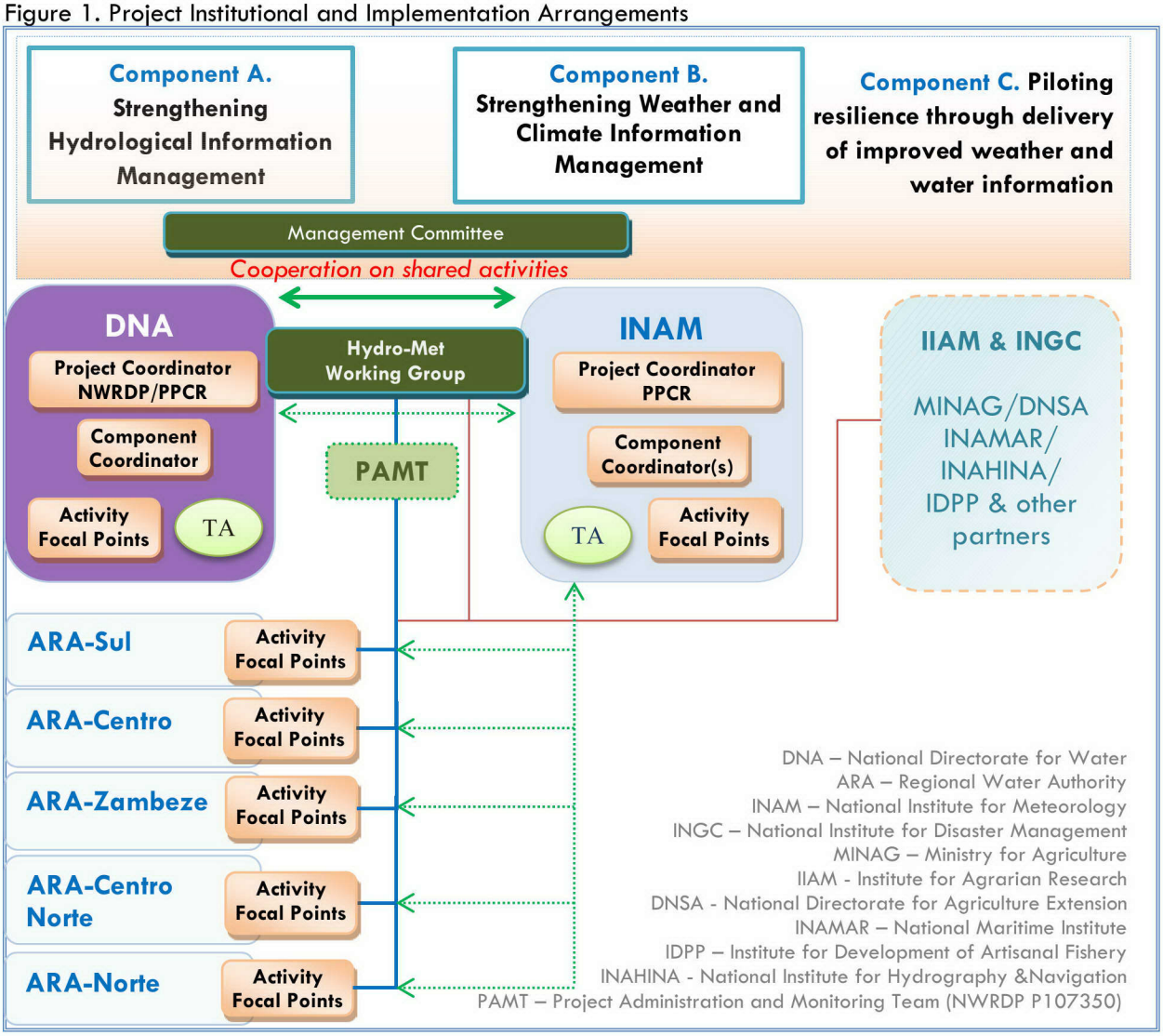
14. **Collaboration with other government agencies.** Component A is aligned with the DNA and the ARAs, and Component B with INAM. This arrangement mirrors the respective policy and legal mandates for hydrology and meteorology respectively, as well as technical expertise within each institution. Notwithstanding, there are activities in each component where all agencies benefit (for example, linking data management systems to improve sharing of precipitation and water flow data, or training that may be useful for both agencies). Furthermore, agencies such as IIAM manage a number of agro-climatological monitoring stations, collect data and disseminate information bulletins.

15. Component C allows for closer collaborations between the agencies where each pilot will be managed by a small team that will include technical specialists from INAM, DNA, ARAs, as well as other relevant government agencies (such as INGC, Radio Moçambique, IIAM, or IDPP etc.). Each pilot will be managed by designated Component Coordinator.

D. Project Implementation Manual (PIM).

16. Under the NWRDP, a PIM was developed outlining roles and responsibilities, planning and fiduciary management procedures. To strengthen the linkages of the proposed Project with the NWRDP, and to streamline implementation, it has been agreed that the PIM will be updated with an additional chapter for the proposed Project. This chapter will outline, in detail, the implementation procedures and schedule, as well as roles and responsibilities of respective institutions and staff members. The updated PIM-chapter (which can also function as a stand-alone document) will clearly outline procedures for communication and for meetings. It will incorporate the guidance procedures of the Environmental and Social Management Framework and the Resettlement Policy Framework. The additional chapter for the hydro-met project is to be completed to the satisfaction of the World Bank prior to Effectiveness.

Figure 1. Project Institutional and Implementation Arrangements



E. The Mozambique Strategic Programme for Climate Resilience (SPCR)

17. The Government of Mozambique has designated responsibility for the Strategic Program for Climate Resilience (SPCR) to the Ministry of Planning and Development and the Ministry for Coordination of Environmental Affairs (who are both PPCR Focal Points).

18. The proposed Project is one of the pilot projects identified in the SPCR and is closely associated with the Climate Change Development Policy Operation (DPO) which contains two Policy Actions directly related to the Project.

19. During implementation, there will be active sharing of lessons learned and knowledge products across the SPCR. Because hydro-met services provide the analytical foundation for understanding climate patters, the projects has a natural role to play in providing the public, other government agencies, academic institutions, the media and private sector, as well as the global climate services community with data and information that can build climate resilience. Knowledge management will also be key – not only with respect to the information products and resources developed – but also in terms of the long-term training that is part of the project and that can extend beyond the implementing agencies (including training tools such as training-of-trainers and effective on-line training).

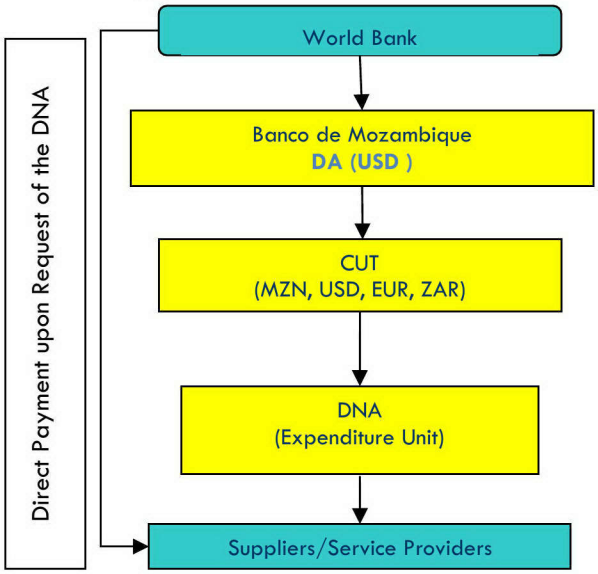
F. Financial Management and Disbursements

20. **Financial Management and Disbursements.** The Project Administration and Monitoring Team (PAMT) established as part of the National Water Resources Management Project has agreed to take on the custodian responsibilities for procurement and financial management of the proposed project. The implementing agencies – DNA, ARAs and INAM – have agreed to this arrangement with respect to the resources and staffing needed to manage the complexities of fiduciary due diligence. The PAMT currently has a Procurement Specialist and a Financial Management Specialist, both of whom worked with the preparation of the National Water Resources Development Project and who are familiar with the Bank's procurement and financial management guidelines and policies. They are also experienced in the national laws and regulations that apply to procurement and financial management in Mozambique (such as using e-Sistafe and the requirements of the Administrative Tribunal).

21. **Accounting.** Similar to ongoing project, this will also use the government integrated financial management information system, e-SISTAFE. The accounting systems, policies, and procedures documented in the Financial Procedures Manual produced as part of preparation of the National Water Resources Development Project will be followed.

22. **Funds Flow.** To facilitate the implementation of the project activities, DNA/MOPH will establish and maintain a segregated Designated Account (DA) in US dollars at Bank of Mozambique (Central Bank) under terms and conditions acceptable to IDA. The project will draw down from the DA on predetermined basis, based on quarterly reports. Funds drawn from DA will be deposited into the Government Single Treasury Account (CUT - Conta Única do Tesouro).

Figure 2. Illustration of the flow of funds



23. **Disbursement Arrangements.** Disbursement of the PPCR grant funds will be made through transaction, including statements of expenditures (SOEs) procedures. The grant funds may be disbursed using the four disbursement methods available: advances, reimbursement, direct payment and special commitments. SOEs will be used to document eligible expenditures paid from the Designated Account or on a reimbursement basis. SOEs should routinely be submitted to the Bank; ideally, every month.

24. An initial advance will be made into the Designated Account upon the effectiveness of the Grant Agreement and at the request of Government of Mozambique. Replenishments to the Designated Account will take into consideration the amount of eligible expenditures reported through SOEs and outstanding balance from previous advances, subject to a maximum authorised allocation (ceiling)

25. **Disbursement to other beneficiaries.** For the proposed project there are a number of beneficiaries, e.g. INAM and five ARAs. Similar to the National Water Resources Development Project, payments related to all activities of the project will be centralised at DNA. Each beneficiary agency will submit the necessary supporting documentation to DNA for processing of payments to be made directly to the providers of goods, works and services financed by the Grant.

Table 5: Eligible Expenditures (US$)

Category	**Amount of the Grant Allocated** (expressed in USD)	**Percentage of Expenditures to be Financed** (inclusive of Taxes)
(1) Goods, Works, Non-consulting services, Consultants' services including auditing, Operating costs and Training	15,000,000	100%
TOTAL AMOUNT	15,000,000	

26. **Auditing.** The project financial statements will be audited by the Administrative Tribunal in accordance with International Standards on Auditing, as promulgated by the International Federation of Accountants (IFAC). The Administrative Tribunal is constitutionally mandated to audit all government projects.

27. The audit report, together with the tribunal's management letter and management response, will be submitted to World Bank within six months after the financial year-end (i.e. June 30 each year). The auditors will be required to express a single opinion on the project financial statements. In addition, a detailed management letter containing the auditor's assessment of the internal controls, accounting system and compliance with financial covenants in the Grant Agreement, suggestions for improvement, and management's response to the auditor's management letter will be prepared and submitted to management for follow-up actions as well as to the Bank along with the audit report.

28. Resources have been provided for under the project to facilitate additional financial reviews and audits of the project's financial statements through the recruitment of private firms as required. The terms of reference for any additional audit or review will be prepared in collaboration between DNA and IDA, if the needs arise.

29. **Supervision Plan.** Financial management supervision will be carried out by the World Bank Financial Management Specialist (FMS) once a year in line with the moderate risk rating. The FMS will also review: i) quarterly IFRs; and, ii) audit reports and management letters from the external auditors and follow-up on material accountability issues by engaging with the TTL, Client, and/or Auditors.

G. Procurement

30. **Procurement provisions and review thresholds**. Procurement for the proposed project will be carried out in accordance with the World Bank's "Guidelines: Procurement of Goods, Works and Non-consulting Services under IBRD Loans and IDA Credits and Grants by World Bank Borrowers" published by the Bank in January 2011 and the World Bank's "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits and Grants by World Bank Borrowers," published by the Bank in January 2011.

31. For National Competitive Bidding (NCB), Mozambican-issued bidding documents may apply. All bidding documents will need to be satisfactory to the Bank and subject to the additional procedures and modifications stipulated below and as reflected in the Grant Agreement.

(a) General. The procedures to be followed for NCB shall be those set forth in the Regulation, with the modifications described in the following paragraphs:

(b) Eligibility. No restriction based on nationality of bidders and/or origin of goods shall apply. Foreign bidders shall be allowed to participate in NCB without restriction and shall not be subject to any unjustified requirement which will affect their ability to participate in the bidding process such as, but not limited to, the proof that they are not under bankruptcy proceedings in the Recipient's territory; have a local representative;

have an attorney resident and domiciled in the Recipient's territory; form a joint venture with a local firm In cases of joint ventures, they shall confirm joint and several liability.

Prior registration, obtaining a license or agreement shall not be a requirement for any bidder to participate in the bidding process.

Recipient's government-owned enterprises or institutions shall be eligible to participate in the bidding process only if they can establish that they are legally and financially autonomous, operate under commercial law, and are not dependent agencies of the Recipient.

(c) Bidding Documents. Standard bidding documents acceptable to the Association shall be used for any procurement process under NCB.

(d) Preferences. No domestic preference shall be given for domestic bidders and/or for domestically manufactured goods.

(e) Applicable Procurement Method Under the Regulation. Subject to these NCB exceptions, procurement under NCB shall be carried out in accordance with the Regulation's public competition (*Concurso Público*) method.

(f) Bid Preparation Time. Bidders shall be given at least twenty eight (28) days from the date of the invitation to bid or the date of availability of bidding documents, whichever is later, to prepare and submit bids.

(g) Bid Opening. Bids shall be opened in public, immediately after the deadline for their submission in accordance with the procedures stated in the bidding documents.

(h) Bid Evaluation. Qualification criteria shall be clearly specified in the bidding documents, and all criteria so specified, and only such criteria so specified shall be used to determine whether a bidder is qualified; the evaluation of the bidder's qualifications should be conducted separately from the technical and commercial evaluation of the bid. Qualification criteria shall be applied on a pass or fail basis.

(i) Evaluation of bids shall be made in strict adherence to the criteria declared in the bidding documents; criteria other than price shall be quantified in monetary terms.

(ii) A contract shall be awarded to the qualified bidder offering the lowest-evaluated and substantially responsive bid.

(iii) Bidders shall not be eliminated on the basis of minor, non-substantial deviations.

(i) Rejection of All Bids and Re-bidding. All bids shall not be rejected and new bids solicited without the Association's prior concurrence.

(j) Complaints by Bidders and Handling of Complaints. The Recipient shall establish an effective and independent complaint mechanism allowing bidders to complain and to have their complaint handled in a timely manner.

(k) Right to Inspect/Audit. In accordance with paragraph 1.16(e) of the Procurement Guidelines, each bidding document and contract financed from the proceeds of the Financing shall provide that: (i) the bidders, suppliers, and contractors and their subcontractors, agents, personnel, consultants, service providers or suppliers, shall permit the Association, at its request, to inspect their accounts, records and other documents relating to the submission of bids and contract performance, and to have them audited by auditors appointed by the Association; and (ii) the deliberate and material violation by the bidder, supplier, contractor or subcontractor of such provision may amount to obstructive practice as defined in paragraph 1.16(a)(v) of the Procurement Guidelines.

(l) Fraud and Corruption. Each bidding document and contract financed from the proceeds of the Grant shall include provisions on matters pertaining to fraud and corruption as defined in paragraph 1.16(a) of the Procurement Guidelines. The Association may sanction a firm or individual, at any time, in accordance with prevailing Association sanctions procedures, including by publicly declaring such firm or individual ineligible, either indefinitely or for a stated period of time: (i) to be awarded an Association-financed contract; and (ii) to be a nominated sub-contractor, consultant, supplier or service provider of an otherwise eligible firm being awarded an Association-financed contract.

(m) Debarment Under National System. The Association may recognise, if requested by the Recipient, exclusion from participation as a result of debarment under the national system, provided that the debarment is for offenses involving fraud, corruption or similar misconduct, and further provided that the Association confirms that the particular debarment procedure afforded due process and the debarment decision is final.

32. Implementation of the procurement activities for the proposed project will be managed by DNA through the PAMT. While there are several beneficiaries to the project, the fiduciary implementation and management has been entrusted to DNA. DNA possesses extensive experience in the management of Bank-funded operations. While the PAMT has been recruited recently, they bring several years of experience in similar operations, enhancing the capacity of DNA as a whole.

33. The assessment of PAMT's capacity to carry out procurement under the project was conducted prior to appraisal and found to be adequate for managing the additional activities from the current project, as the PAMT is staffed with qualified personnel, including an experienced procurement officer. The key issues and risks concerning procurement for implementation of the project have been identified and include:

i) the coordination between the PAMT and the beneficiary institutions for the timely implementation of agreed activities; and
ii) delays caused by Government's own review process prior to contract signature, including the approvals from Mozambique's Administrative Tribunal.

34. To ensure acceptable project implementation satisfying minimum Bank fiduciary requirements, corrective measures were discussed and agreed with DNA and include:

i) the need for each beneficiary institution to have a designated Component Coordinator and Activity Focal Points; and

ii) the procurement planning process taking into account the steps and associated timeframe for Government's own process of approval.

35. In view of the overall experience and capacity of DNA to carry out procurement activities related to the proposed project, the procurement risk associated with the project is rated as *Moderate*.

36. **Prior-Review Thresholds.** Prior-review and procurement method thresholds for the project are indicated in Table 6 below and will be incorporated into the Procurement Plan and the updated PIM for the procurement provisions under the proposed Project.

Table 6: Procurement Thresholds

		Procurement Method Thresholds Proposed (USD million)							
		ICB	NCB	Shopping	QCBS	CQS	LCS	DC / SSS	ICS
Works		N/A	<5.0	<0.05				All	
Goods		≥0.50	<0.50	<0.05				All	
Consulting Services	Firms				≥0.20	<0.20	<0.20	All	
	Individuals							All	≥0.10

37. The Project is not expected to finance large-value Works contracts that would normally be subject to pre-qualification and or international competition.

38. **Procurement Plan and Procurement Arrangements.** The Procurement Plan for the project was prepared by DNA and reviewed during Appraisal. This plan will be updated annually or as required to reflect the project implementation. *Works* contracts are expected to be procured primarily through NCB and Shopping procedures and will be related to the installation, rehabilitation and upgrading of hydro-met monitoring stations along the rivers in catchment areas as well as strategic locations for monitoring weather patterns. *Force Account* may be used where workers for the rehabilitation of hydro-met monitoring stations are required to be hired in the vicinity of the works, such as bricklayers, carpenters and locksmiths. The same may apply when the use of Government agencies' own staff will be advantageous in view of interventions being scattered geographically. *Goods* to be procured will include vehicles, motorcycles, information technology, office equipment, equipment for gauging and metering stations, among others. *Consultant's services* to be financed will include the design study of hydrological monitoring networks, design and implementation of an Integrated Information Platform, hydrological modeling and forecasting, weather prediction modeling and forecasting, amongst others. *Non-consultant services* will include: the upgrading of critical software and other ICT investments for the transmission, accessibility and management of data, as well as data rescue, digitisation and integration, the upgrading of early warning systems and functions, targeted surveys of user needs for development of hydro-meteorological information products, and calibration of monitoring networks, amongst others.

39. Generally, the World Bank Standard Bidding Document for Works and Goods and the Standard Request for Proposals as well as NCB documents satisfactory to the Bank will be used for contracts to be procured. These documents are presented in the procurement section of the Project Implementation Manual (PIM) developed as part of the NWRDP. The PIM will be updated with an additional chapter for the proposed Hydro-Met Project.

H. Management of Environmental and Social (including safeguards)

40. **Environmental and Social (including safeguards).** The application of the Bank's safeguard operational policies[51] was assessed as part of the project concept review in February 2012. At the review meeting, it was agreed that the project would be classified as Environmental Category B. The policies triggered by the proposed Project are OP/BP 4.01 Environmental Assessment, OP/BP 4.04 Natural Habitats and OP/BP 4.12 Involuntary Resettlement.

41. Overall, it is expected that there will be limited negative impacts on the environment or humans due to the minor nature of the civil works involved. However, certain physical interventions associated with any construction of new and rehabilitation of old weather and water monitoring equipment (such as automatic monitoring stations and river stage gauges/plates) calls for routine screening procedures to adequately identify and manage associated impacts (in line with the Environmental Management Framework-Environmental Management Plan for small project typologies). These screening procedures would relate to any impacts for installation or rehabilitation works, such as how to choose appropriate locations for equipment with respect to access (from existing roads) and avoidance of any land (such as farm land or any new access road/paths if deemed necessary). In certain cases where new stations are needed, there may be a need to establish a pathway or access road. They are typically simple in nature, and with limited traffic (by foot/bicycle for readers to collect data, or with vehicle/motorcycle to undertake operations and maintenance). Should any new land be required, then the Resettlement Policy Framework guides the mitigation measures in line with World Bank Operational Policy OP/BP 4.12 Involuntary Resettlement and the Mozambican Regulation for Resettlement Resulting from Economic Activities (Decree No. 31/2012 of 08 August/Regulamento sobre o Processo de Reassentamento Resultante de Actividades Económicas). The Project does not foresee any reason to require riparian notification requirements because the limited and small scale equipment would not affect water use (abstraction or flow) affecting riparians.

42. During preparation, an Environmental and Social Management Framework (ESMF) was developed and disclosed in country and in the Bank's Info-Shop.

Table 7. Safeguard policies triggered by the project

SAFEGUARDS POLICIES TRIGGERED		
Environmental Assessment (OP/BP 4.01)	Yes	
Natural Habitats (OP/BP 4.04)	Yes	
Pest Management (OP 4.09)		No
Indigenous Peoples (OP/BP 4.10)		No
Physical Cultural Resources (OP/BP 4.11)		No
Involuntary Resettlement (OP/BP 4.12)	Yes	
Forests (OP/BP 4.36)		No
Safety of Dams (OP/BP 4.37)		No
Projects on International Waterways (OP/BP 7.50)		No
Projects in Disputed Areas (OP/BP 7.60)		No

[51] Under the PPCR, Phase 1, a Social and Environmental Impact Assessment will tentatively be developed. Any findings from the ESIA would be considered by the Project as this becomes available.

I. Monitoring and Evaluation

43. A Results Framework (RF) was developed during project preparation to reflect the expected improvements to hydro-met services, including PDO- and intermediate-level indicators. As the project is part of the PPCR, the Results Framework includes several PPCR indicators (recommended and Core-indicators) established in November 2012. The World Bank's Core indicators have been reviewed and incorporated as appropriate as well. In addition, the RF includes indicators that directly monitor the progress of the hydro-met Policy Actions in the Climate Change DPO.

44. Progress in the M&E indicators listed in the RF will be monitored as part of supervision missions and reported in the semi-annual ISRs and Aide Mémoires. In addition, DNA contributes to the broader water sector M&E framework, in which project achievements will also be assessed. As part of INAM's annual Action Plans to be developed in Component B, progress related to the meteorological investments will be assessed. The capacity to collect data varies across the agencies. Therefore, monitoring tasks will be integrated into the activities of the Action Plans, annual reviews of the status of the monitoring networks, user surveys, and evaluation of the pilots.

J. Role of Partners (if applicable)

45. The NDF is providing parallel financing in the order of €4.5 million. The NDF will specifically fund parts of Component B in support of meteorological services. NDF provides funds in as many as four large contracts. Support will primarily fund technical assistance, institutional strengthening and organisational development (Activities B1, B2 and B3) as well as earmarked civil works and goods under remaining activities under Component B. The NDF will join supervision missions of the Bank; all of the Bank's procurement procedures apply. The only deviation from Bank procedures is that any request for expressions of interest will be posted on NDF's website.

46. Other partners support activities associated with hydro-met or the implementing agencies that have been consulted during preparation. During implementation, other partners will continue to be consulted to improve alignment and avoid duplication of efforts and procedures. Associated partners and activities include, for example:

(a) the Mozambique Red Cross pilots for the establishment of the Local Disaster Management Committee, now incorporated in the INGC;

(b) UNDP supports strengthening local risk management and mainstreaming disaster risk reduction[52], coping with drought and adaptation to climate change[53] and the African Adaptation Programme[54] (AAP). Activities under these programs that relate specifically to the World Bank's efforts for strengthening hydro-meteorological services include: consolidation of the Licungo River basin early warning system (with INAM); training of district directors of planning and infrastructure, and provincial secretaries (with MICOA and INAM); establishment of a Climate Change Knowledge Center; and the Indian Ocean

[52] http://www.undp.org.mz/en/What-we-do/Crisis-and-Environment/Ongoing-Projects/Strengthening-Local-Risk-Management-and-Mainstreaming-Disaster-Risk-Reduction-DRR
[53] http://www.undp.org.mz/en/What-we-do/Crisis-and-Environment/Ongoing-Projects/Coping-with-Drought
[54] http://www.undp-aap.org/countries/mozambique

Consortium and UNDP project "Strengthening Tsunami Early Warning and Response System in Mozambique," completed in 2011 and financed through UNISDR (UN International Strategy for Disaster Reduction);

(c) Germany/GIZ supports a number of relevant regional and national initiatives from where project implementation can draw lessons and find mutually beneficial synergies. These include: Adaptation to Climate Change in Rural and Urban Areas of Mozambique including EWS in Buzi River basin and Beira (strong working platform with INGC, INAM and ARA-Centro with cooperation between Mozambique, Brazil and Germany); and Transboundary Water Management in the SADC region for 2005-2015 (refining data collection, sharing and management), among others.

(d) the African Adaptation Programme includes: training of district government staff to collect climate information to reinforce the national climate database; development of an interactive decision support system for hazards (urban, rural, coastal) solutions; establishment of an early warning system to provide climate change information, including rehabilitation of community radios in Chicualacuala and the Guija districts; strengthening the database and information management system for water resources; completion of the climate data rescue effort; development of user interfaces for INAM's database to demonstrate applicability of historical and current data to different sector needs; information sharing mechanisms established, through the ACC Knowledge center, with regional and international platforms.

(e) the UN Development Assistance Framework (UNDAF) 2012-2015[55] - Economic Section, the World Food Programme is the lead agency for the project "Geo-Information for Disaster Management in Mozambique", primarily targeting INGC, CENOE, MICOA and MINAG. However it also includes efforts to create a spatial database for the country, as well as provision of a web-based flood monitoring system – for response coordination and decision-making – utilising satellite sensing.

[55] http://mz.one.un.org/eng/Resources/Publications/UNDAF-2012-2015

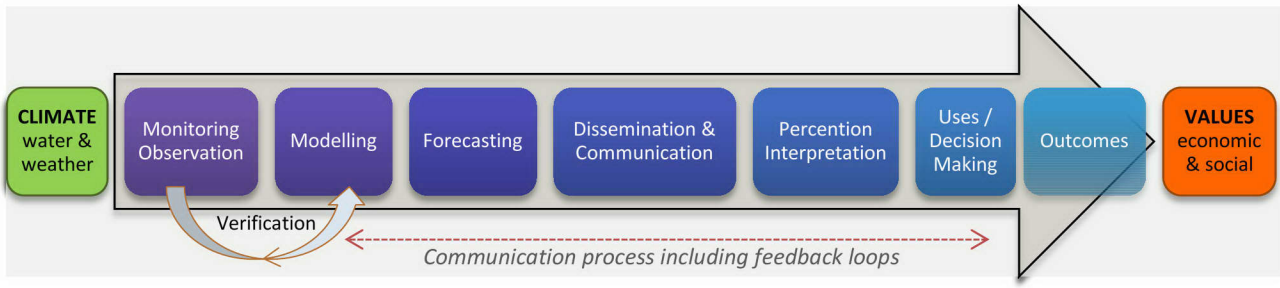
ANNEX 5: ECONOMIC ANALYSIS

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services

1. To estimate the value of strengthening Mozambique's hydro-meteorological services, an economic analysis is being completed by assessing costs and benefits of the proposed project. The desired outcome of the benefit cost analysis (BCA) is to verify the economic justification for the project, guide the project's priorities and investments during implementation, position the value of Mozambique's hydro-met services in a wider sociopolitical context, and create a baseline against which progress can be compared.

2. A hydro-meteorological value chain shows that value, in economic and social terms, is ultimately at the end of the process that starts with observation of climate through to decision-making and outcomes. As such, the value of an accurate, timely and relevant forecast can only realized if a beneficial value is achieved at the end of the process. Often, it is assumed that by merely improving observation - through improved technologies for example - an end economic value will be secured.

Figure 3: Simplified hydro-meteorological value chain



3. The assumed benefits derived by different economic sectors are estimated through a benefits transfer method[56]. In addition, a more detailed economic analysis is underway to combine the findings from the benefit transfer estimates with data collection from two primary sources. The latter two will include expert elicitation from interviews with sector experts, and a household public survey. The costs in the BCA calculation are those associated with the project's investments. The approach was chosen due to the relatively limited experience of the stakeholders on value-estimation, and that it is the end-change in value created by users that is being assessed in the economic analysis. The BCA includes sensitivity analysis of a number of key parameters (including discount rates, timelines of investment and benefits realisation) and explication of reasonable and identifiable omissions, biases and uncertainties. Although the implementation period for the project is estimated at five years, the benefits can in theory be derived far beyond 2017 provided adequate repair, upgrade and maintenance. With a non-zero rate of discount for all intents and purposes, the present value of far future benefits and costs will asymptotically approach zero so the time horizon of 50 years was used.

[56] BCA methods such as computable general equilibrium models or social accounting matrices are not relevant as they do not adequately estimate the value of information.

BENEFITS

4. The methodology for benefits transfer is based on sourcing data from related benefits studies and publications on similar issues, and adjusting benefits (transfers) to the specific topic. Additionally, information was collected during preparation on the current benefits of hydro-met services. Due to limited data availability, the analysis's assumptions are explained and subject to sensitivity analysis in the aggregation and calculation of the net present value (NPV). There is likely overlap in the three underlying approaches to benefit estimation (benefits to households, value of statistical lives saved, and sectoral benefits of improved forecasts outlined below) and each was treated individually and their total present value to the total present value of costs were compared.

5. **The Benefits Transfer Analysis of value for households shows that the annual benefits of moderately improved forecasts and warning are approximately US$19 million.** A benefits analysis by Lazo and Chestnut (2002) on US households' willingness-to-pay (WTP) showed that the value of improvements of forecasts was related to household social, economic and demographic characteristics and that most value was put on next-day forecasts. A per household willingness to pay of US$19/yr for significantly improved forecasts was derived in Lazo and Chestnut and adjusted to the Mozambican analysis. Adjustments made of the above-mentioned study of significantly improved forecasts, to a 2011 estimate of Mozambique's WTP of moderately improved forecasts and a population of 23 million, aggregated to an annual benefit of approximately US$19 million. An income elasticity of the value of statistical life (VSL) of 0.4 (Viscusi) was used to adjust the WTP to the Mozambican analysis.

6. **Benefits transfer analysis on the reduction of natural hazards impact derived an annual total national value of statistical lives saved (0.593 statistical lives per year) of US$1.45 million.** Weather and water related disasters include both fatalities and economic impact (the latter includes losses, response/recovery costs and longer-term structural impacts). In Mozambique, impacts are particularly long-lasting due to debilitating prevalence of diseases such as malaria and hiv/aids, and absence of infrastructures that can buffer impacts (such as levies and poor drainage in low-lying and highly populated areas). Between 1980 and 2011, a total of 101,837 fatalities were caused by hydro-meteorological events (EM-DAT) of which a majority were associated with a 5-year drought cycle affecting southern Mozambique. Because a portion of fatalities can be reduced with improved forecasts, the associated benefits are estimated using a value of statistical life (VSL) approach. The 1980-2011 average number of lives lost to weather related disasters was 59.3 not counting the 1981-1985 drought impacts in southern Mozambique. Assuming 10% fewer would be lost with perfect forecasts and of these 10% so with the proposed project indicates about 0.593 fewer fatalities per year due to the project. To calculate the VSL, individual WTP to reduce the risk of death were estimated. From an extensive body of literature, a common point estimate is a US$6 million VSL. For Mozambique, the VSL (i.e., value or reducing risk of loss of one life) was scaled to US$2.45 million. This value was then multiplied by the expected reduction in loss of life (0.593) for an annual benefit of US$1.45 million.

7. **Benefits transfer analysis of variability of economic output attributable to weather variability and day-to-day impacts derived an annual total national sector value of improved forecasts of US$3.56 million.** In Mozambique, economic sectors are assumed to be relatively more sensitive due to the lower levels of investment in hydro-met mitigation capital. Lazo et. al. (2011) estimated that total U.S. economic output (GDP) ranges by up to 3.4% of

gross domestic product a year owing to weather variability. Applying US sectoral sensitivity estimates aggregated to the Gross National Income (GNI) of the three primary Mozambican sectors (agriculture, industry, and services) multiplied by initial estimates of (a) the percent reduction in impacts under perfect forecasts and (b) the portion of those perfect forecasts achievable with the current project (both assumed to be about 10%) generates an estimated reduction in the range of weather related GNI variation with the project of US$25.32. We adjust this using the coefficient of variation in Lazo et al relative to the full range of GDP variation and the properties of the normal distribution (50% of a normal distribution lies within 0.67448 standard deviations of the mean) to derive an average annual benefit of US$3,56.

COSTS

8. **The costs associated with the proposed Project are a total of US$20.7 million.** The total investments are assumed to be portioned evenly across the project implementation period of five years (i.e., US$4.14 million/yr). During and beyond implementation, costs will be incurred for operation and maintenance (O&M) and repair at an assumed 10% of total project investment (i.e., US$2.07 million/yr) for the time period of the analysis.

AGGREGATED COSTS AND BENEFITS

9. Table 8 below summarizes the key variable for the benefit-cost analysis including timing of benefits and costs and the discount rate. For all calculations, real values were applied that do not factor in inflation or potential changes in exchange rates. A discount rate of 3% was applied as a lower discount rate will give more weight to the social benefits side (the sensitivity analysis was re-run with 10% but this did not substantively change results).

Table 8. Key Variables for Benefit Cost Calculations

Key Variables	Value
First year of costs	**2013**
Annual cost of initial investment (Millions USD)	4.14
Timeline of initial investment (Years)	5
Annual maintenance and repair (% of initial investment)	10%
Timeline of increasing operation and maintenance costs (start after investment starts) (Years)	5
Value to households	$18,792,743
Value of statistical lives saved	$1,453,164
Sector value of improved forecasts	$3,562,178
First year of benefits	**2013**
Last year of benefits w/o ongoing support	2016
Last year of benefits w/ ongoing support	50
Discount rate	3%
Discount rate - range for sensitivity analysis	1-10%

10. **A present value of total costs of US$70.37 million was estimated** using the 50 year timeline, the basic assumptions, and a 3% rate of discount.

11. **The net present value to households is over US$391.17 million** with a benefit-cost ration of 6.56 using the baseline assumptions and a 3% rate of discount.

12. **The net present value of lives saved is US-$34.68 million**. The potential lives saved from natural disasters, is only a portion of the likely total benefits and thus should not be considered an estimate of the total value of the project. Instead we could consider the value of lives saved alone to cover 51% of the total cost of the project (benefit cost ratio of 0.51) with significant values accruing elsewhere in society and the economy. In theory, the value of lives saved could be included in households WTP if they considered that as part of the assessment of the value of improved forecasts.

13. **A net present value of over US$17.12 million is estimated** using the sectoral benefits approach. Again, this cannot be added to the household values as in theory households would consider these values in the mental calculus of their WTP – in essence the sectoral benefits accrue to households as income (whether through wages or profits) as the ultimate actors in the economy. It is therefore reasonable to use the net present values of US$17 million to US$391 million as the baseline estimate for the project.

Table 9. Benefit Cost Results (all values 2011 USD)

	Present value total costs	Present value benefits to households	Present value benefits of statistical lives saved	Present value sector benefits of improved forecasts
Total Present Value	**70,366,054**	**461,532,215**	**35,688,351**	**87,483,764**
Net Present Value		**391,166,161**	**-34,677,703**	**17,117,711**
Benefit Cost Ratio		**6.56**	**0.51**	**1.24**
Discount rate 3%				

SENSITIVITY ANALYSIS

14. **The sensitivity analysis strongly suggests the need for better evaluation of parameters for project evaluation.** A basic sensitivity analysis was done with respect to assumptions on the discount rate, potential improvements in forecast quality and ongoing support from the Government of Mozambique or other unidentified agencies. Results are relatively insensitive to the discount rate and the same policy recommendation emerges whether using a 1%, 3% or 10% rate of discount.

15. If the improvements in forecasts are less than assumed in the baseline BCA, a significant reduction in NPV is expected. Assuming only 20% rather than 50% of the improvement in Mozambique are achieved, NPV of household benefits fall by roughly 70%. If the percent of sectoral impacts avoidable with perfect forecasts are respectively 10% rather than 20%, the NPV becomes negative. Finally, if there is no budget increase for the relevant agencies to support project operation and maintenance, the NPV estimates fall precipitously, In this case, while potentially having a positive NPV due to the short term benefits, it is assumed to generate no benefits after the system degrades again to pre-project levels within a few years.

Table 10. Sensitivity Analysis – Benefit Cost Results (all values 2011 USD)

Sensitivity Analysis	Parameter Value	NPV Households	BCR Households	NPV Sectoral Analysis	BCR Sectoral Analysis
Baseline		391,166,161	6.56	17,117,711	1.24
Discount Rate	1.0%	608,611,150	7.20	35,823,369	1.37
Discount Rate	10.0%	134,579,262	4.73	-3,714,267	0.90
Percent improvement in forecast[1]	See Footnote 1	114,246,833	2.62	-48,495,110	0.31
Failure to support budget for long-term operation, maintenance, and repair[2]	See Footnote 2	64,102,743	4.28	-3,676,370	0.81

[1]Table "Value of adjustment for level of forecast improvement" set to 20% instead of 50% and values for "Percent reducible with perfect forecasts" and "Percent of perfect forecasts achievable with project" each set to 5% instead of 10%.
[2] Assumes that there is no spending on operations maintenance and repair above and beyond the initial investment. Assumes that the benefits realized in the first five years then degrade proportionally over the following four years as the system returns to current (prep-project) status.

16. In the baseline analysis an income elasticity of VSL of 0.4 was used to adjust the WTP to the Mozambican analysis. Some literature suggests the use of a higher income elasticity of VSL which implies a lower VSL in Mozambique. Using an income elasticity of VSL of 1.0 represents a VSL adjustment directly proportional to the income difference to a VSL Mozambique of US$123,720 which multiplied by the lives per year 0.593 represents a value of lives saved per year US$73,366. Applying the rest of the baseline assumptions with this lower VSL results in a NPV of lives saved of US$-68,564,254 and a benefit cost ratio of 0.03.

OMISSIONS, BIASES, UNCERTAINTIES

17. Few economic studies can consider all of the potential benefits and costs of a specific project, especially with respect to all of the potential secondary and tertiary effects and we therefore identify qualitatively some of these potential omissions.

18. The potential value of climate information from longer and more reliable climate record for Mozambique as a result of the project would benefit longer term planning for infrastructure such as dams and water resources, energy and transportation facilities, and critical uses of climate information to build resilience against climate extremes (including modeling for climate change impact assessment and mitigation).

19. The potential value of increased in-country capacity from the project's investment into development of human capital, improved training and education, and improved management systems among other anticipated outcomes, may all have secondary and tertiary benefits to the agencies as well as to the country as a whole.

20. The potential value of contribution to global weather forecasting data would help strengthen global forecasting models as they are based on data input from all areas of the globe at a range of spatial and temporal scales across all measures of hydro-meteorological characteristics. The skill and value of global forecast models is presumably a non-decreasing function of the quality of the data inputs. As Mozambique has been a data sparse area, the project will potentially provide useful data to global data modeling efforts. Benefits could be accrued both globally and eventually back to Mozambique.

21. The potential value of reduced impact of natural hazards on economic development,

according to some studies; suggest a positive relationship between disasters and long-term economic development for instance if damaged capital is replaced with more efficient capital. Other studies argues the contrary (Toya and Skidmore. 2004, Kellenber and Mobarak 2011; Hallegatte 2012). As the magnitude and direction of these longer term impacts is still being debated in the literature, the economic analysis has not attempted to quantify the benefits or costs thereof.

22. At the current time and likely in the future, hydro-meteorological information will be available from sources other than the official Mozambican implementing agencies (DNA, the ARAs and INAM). Anecdotal evidence suggests that there currently is better weather forecast information available online than what is provided by the GoM. If the project to improve hydro-meteorological information services in Mozambique cannot compete with or provide value-added above and beyond alternative weather information sources it is arguable that the potential benefits of the project are less than estimated. This could be a significant factor to consider in evaluation of the net benefits of the project.

ANNEX 6: OPERATIONAL RISK ASSESSMENT FRAMEWORK (ORAF)

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services

Stage: Board

Project Stakeholder Risks				
Description : Risk of absent long-term commitment from the Government of Mozambique in strengthening its hydro-meteorological information services to help build climate resilience, reduce the impact of extreme water and weather events or enhance productivity (a lack of commitment for institutional change and sufficient budget may translate into lack of sustainability of the project investment).	Rating	Moderate		
	Risk Management: The proposed Project has designated activities to improve commitment at an institutional level (through the design and implementation of Action Plans for example, to long-term training of technical staff), at an end-service level (through improved understanding of user need in surveys, to tailoring information products to better interact with users), and at the technical level of hydro-meteorology (through reinforcing the monitoring network to improve the accuracy of data as a foundation to the hydro-met value chain). The combined effort to strengthen both physical and human capacities will help uphold more opitimised hydro-meteorological monitoring systems for the benefit of better forecast and tailoring information to users. An assessment of the economic benefits from strengthening hydro-meteorological services in Mozambique is being completed in 2013. The research will enhance the dialogue with partners and decision makers on the long-term value of hydro-met services. This is despite the difficulties in attributing direct relation to input and outputs with this type of intervention. However, such assessments can also help illuminate the benefits gained with the financing needs that the GoM and international donors are required to maintain for the relevant services and responsible agencies.			
	Resp: WB, GoM	Stage: Impl.	Due Date : 2018	Status: ongoing
Implementing Agency (IA) Risks (including Fiduciary Risks)				
Capacity	Rating:		Moderate	
Description : Risk of lacking sustainability of physical investments into monitoring equipment through inappropriate design and lack of staff and resources for adequate monitoring and operation. The technical diagnostic completed during project preparation revealed that roughly 37% of manual river monitoring stations are providing some data (primarily	Risk Management: The project design reflects a comprehensive approach to addressing the needs to sustain the investments into hydro-met. The approach is built on equally strengthening the institutional capacity to operate and maintain hydro-met monitoring (through reform, training, planning and mechanisms for cooperation across ministries) as well as designing the more appropriate program of rehabilitating existing monitoring stations as well as introducing modern technologies for more automatic monitoring (through building a more consistent and integrated monitoring network and system, and through strengthening engagement of the hydro-meteorological readers).			

through readers), and only 25% of the manual weather stations. Equally, staffing resources are low and lack of motivation persists (from staff to more advance).	Resp: WB, GoM	Stage: Impl.	Due Date : 2018	Status: ongoing
Governance				
Description: The project interventions are, by default, spread across ministries and agencies, and across vast geographic areas. This requires a complex governing structure, yet flexible enough to match the existing agencies.	Rating	Moderate		
	Risk Management: A Hydro-Met Working Group established during preparation will be formalised during implementation. The effectiveness of the Group depends on the mandates of the members and ability to share and cooperate on joint activities. On the expressed preference of the implementing agencies, the outcome of a number of activities will rely on the equal participation of the implementing agencies (for example, the rainfall data collected by the ARAs is critical for the precipitation forecasts done by INAM; and vice versa the quality control done by INAM and their access to WMO data can enhance the flood forecasting done by the ARAs and DNA. With the PAMT in DNA being responsible for the administration, reporting and fiduciary management of the Project, key governance aspects of the project will be centralised and assist in improving the effectiveness of project delivery.			
	Resp: WB, GoM	Stage: Impl.	Due Date : n/a	Status: ongoing
Project Risks				
Design				
Risk of not designing the most optimal activities for rehabilitation and installation of new hydro-meteorological monitoring systems.	Rating:	Low		
	Risk Management : Project preparation has identified key areas for investment and project activities includes detailed design and prioritisation of interventions. During early implementation, the implementing agencies will benefit from the more detailed design studies to be undertaken that will help in the prioritisation, meta-data inventory upgrade and consistency checks of the proposed investments.			
	Resp: WB, GoM	Stage: Impl.	Due Date : n/a	Status: ongoing
Social & Environmental				
Risk of any negative impact on local environment or society/human settlement and activity from rehabilitation of monitoring networks or installation of new water and weather monitoring stations.	Rating:	Moderate		
	Risk Management : With any installation of new weather and water monitoring equipment (such as river gauge plate or wind gauge), the Environmental Category B classification has been agreed to stipulate the appropriate screening procedures. In line with Bank recommendations, these include an abbreviated Environmental and Social Management Framework/screenings for small project typologies and a Resettlement Policy Framework. The ESMF and RFP have been completed and disclosed January 22, 2012. It is highly unlikely that the project will require land acquisition, and instead could initially seek vacant land that is owned by the government. If, it is determined that if land acquisition is necessary, the Resettlement Policy Framework will provide guidance on the remedial actions to mitigate and compensate any loss, as well as identify how best an abbreviated resettlement action plan (if the impacts are minor) will be drafted, approved and implemented.			

	Resp: WB, GoM	Stage: Impl.	Due Date : n/a	Status: ongoing
Program & Donor				
Risk of incompatible donor support to implementing agencies challenging the achievement of PDO.	Rating:	Low		
	Risk Management: The WB team is in continuous dialogue and coordination with other donors and NGOs such as JICA, UNDP, WFP, Embassy of the Netherlands, Embassy of Finland, Sida, Swiss agency for Cooperation, Red Cross and others. This dialogue provides an opportunity to share updates on project design and outcome, as well as how best to harmonise various areas of support. Co-financing options will continue to be explored to expand the reach of the Project and avoid duplication of donor efforts and demand on client.			
	Resp: WB, GoM, donors	Stage: Impl.	Due Date : n/a	Status: ongoing
Delivery Monitoring & Sustainability				
Description : Risk of rehabilitation/installation of monitoring stations and networks not functioning due to bottle-necks/disruption to transfer and delivery of hydro-meteorological data.	Rating:	High		
	Risk Management: There are multiple factors that determine accuracy and timeliness collection, transfer, processing and delivery of information products to end-users. Further, with hydro-meteorological systems the objective is not to create perfect static systems. Rather, these systems and networks are inherently changing and facing problems at different nodes. Therefore, the project will incorporate the needs at different stages of this chain of data management and with robust calibration, O&M procedures (covered by project budget costs including deferred maintenance costs), Quality Management Systems, and M&E systems in place, obstacles can be managed. Additionally, the project will provide support for training and technical assistance that will strengthen the institutional, technical, and management capacities that will provide for the long-term sustainability of the project's physical investments.			
	Resp: WB, GoM	Stage: Impl.	Due Date : n/a	Status: ongoing
Overall Risk Ratings:				
Implementation	Rating:	Moderate		
Comments: The *Moderate* risk rating is proposed due to fragmented nature of institutional mandates and implementation arrangements, the risks to financial sustainability and the geographic spread of investments.				

ANNEX 7: IMPLEMENTATION SUPPORT PLAN

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services

1. **Strategy and Approach for Implementation Support.** The complexities and integrated nature of the project, along with its associated risks, inform the implementation strategy. Implementation support (IS) will give priority to technical expertise needed to support optimised and sustained hydro-meteorology solutions, to integration and enhancement of interagency cooperation, and to the fiduciary and safeguards procedures that apply to the project.

2. **Implementation Support Plan**. Key priorities for the team missions will be to ensure that the detailed design of hydro-met investments are realistic and proceed effectively, to provide assistance and 'trouble-shooting' of any emerging bottlenecks, and to monitor factors that undermine the sustainability of the project (such as financing, institutional capacity, or lack of operations and maintenance). Another focus for supervision and support missions will be to ensure that the counterpart agencies are adequately staffed with technical, procurement, financial management and safeguard specialists. In addition, the Bank will provide support in the review of key procurements from both technical and fiduciary aspects.

3. Although supervision missions are planned on a semiannual basis, more frequent visits will take place. The bank team will explore opportunities to effectively collaborate with cooperating partners and with regional hydro-met initiatives in neighbouring countries such as South Africa and in strategic basins such as the Zambezi, Incomati, Limpopo and Púnguè Rivers. Access and integration of best-practice research and global knowledge will be pursued in cooperation with the WMO and the Global Framework for Climate Services, the Global Facility for Disaster Reduction and Recovery (GFDRR) and the Pilot Program for Climate Resilience (PPCR).

4. Regular contact will be maintained with the Project's respective Component Coordinators and Activity Focal Points in each implementing agencies. Progress will be monitored against an agreed work plan and through quarterly joint reporting in an agreed format. Although the team's staff are spread across offices in Pretoria, Washington, D.C. and Geneva, the team comes together for missions and maintains regular communication.

Skills Needed	Staff Weeks/ Year	No. of Trips	Comments
Task Team Leader	12	As required	Country office-based
Co-Task Team Leader	12	As required	Washington DC-Based
Meteorologist	6	As required	Country office-based
Hydrologist/Water Resources Specialist	4	As required	HQ-based
ICT Specialist	4	As required	HQ-based
Climate Change/DRM Specialist	4	As required	Country office-based
Economist	2	As required	Consultant
Operations Analyst	6	As required	Washington DC-Based
Team Assistant	8	As required	Country office-based
Environment Specialist	3	As required	Washington DC-Based
Social Specialist	3	As required	Washington DC-Based
Procurement Specialist	2	As required	Country office-based
Financial Management Specialist	2	As required	Country office-based
Communication Specialist	2	As required	Country office-based

ANNEX 8: TECHNICAL ANALYSIS OF MOZAMBIQUE'S HYDRO-MET SERVICES

Mozambique Climate Resilience: Transforming Hydro-Meteorological Services Project

A. Background

1. Mozambique's meteorological observations started in 1883 in the second largest city of Beira at the time of Portuguese colonial rule. In 1950, the Mozambique Meteorological Services (Servico Meteorologico de Moçambique) was founded and continued operating after independence in 1975. The level of observation declined rapidly in succeeding years however, and particularly during the 15-year-long civil war that ended in 1992. In the 1990s and early 2000s, expanding hydro-met monitoring and forecasting was challenged by a number of factors, including: lack of adequate and qualified staff, financial resources, competing development priorities, and equipment failure, among others. The floods of the early 2000s in southern and central Mozambique highlighted the need to revitalise the government's capacity in forecasting extreme water and weather events, early warning systems and disaster management. Donor support flowed into the country and enabled a series of hydro-met improvements – including installation of telemetric stations in the Incomati and Limpopo, strategic SADC HYCOS stations, construction of two Doppler Radars in Beira and Xai-Xai, training and technical assistance, etc. Equally, the Government of Mozambique (GoM) has shown political commitment to modernising the hydro-met services as a measure to build resilience against natural disasters and climate change, in addition to supporting productive sectors. This commitment is articulated in key documents such as the 2001 Water Policy, the Decree for the establishment of INAM in 1989 (10 October 1989, Decree 30/89), the National Water Resources Management Strategy of 2007 (ENGRH, Estratégia Nacional de Gestão de Recursos Hídricos), and the 2007 National Adaptation Programme of Action (NAPA).

2. With future climate change, the need to reinforce Mozambique's hydro-met services has become ever more important. The proposed Project aims to support the Government in realising its commitment to build climate resilience, enhance disaster management and support productive sectors through improved hydro-met services. The Project design is characterised by three fundamental principles: first, adoption of a comprehensive approach to hydro-met services including both necessary and appropriate technical investments, as well as skills-development and interagency cooperation; second, by emphasis on financial and institutional sustainability; and third, strengthening of the agencies' abilities to tailor information services to meet critical end-user needs.

B. Institutional Mandate and Organisational Structure of Hydro-Met Services

3. **The GoM's institutional mandate for hydrological and meteorological information services is divided between two ministries and seven respective agencies, which shapes the effectiveness of service delivery.**

4. The mandate for hydrological monitoring and forecasting is governed by the Water Law (No. 16/91 August 03, 1991) and the 2007 National Water Resources Management Strategy. Institutional responsibility for hydrology resides in the Ministry of Public Works and Housing (MoPH, Ministério das Obras Públicas e Habitação - Ministerial Diploma 217/98) under which the National Directorate of Water (DNA, Direcção Nacional de Águas) has the responsibility for

the strategic management of water resources. Within DNA, the Department of Water Resources (DRH, Departmento de Recursos Hídricos) are responsible for collective data management, quality standards, modelling and forecasting. DRH also provides guidance and technical guidance to the five Regional Water Authorities (ARAs, Administrações Regionais de Águas). The ARAs are public institutions, divided among key groups of river basins, and operationalise the strategic activities managed by DNA (Ministerial Diploma 134/93, November 17). The relevant tasks of the ARAs are to manage monitoring networks, collect and send data to DNA and other stakeholders at the basin level, perform flow forecasting, and manage water infrastructure. These tasks are organised according to River Basin Management Units (UGB, Unidade de Gestão da Bacia). The ARAs consist of ARA-Sul, ARA-Centro, ARA-Zambeze, ARA-Centro Norte and ARA-Norte.

5. The mandate for hydrological monitoring and forecasting is articulated in Resolution 30/89, which created the National Institute for Meteorology (INAM, Instituto Nacional de Meteorologia) in 1989. INAM's core responsibility is to monitor and forecast weather and climate, and to produce and disseminate climatological data, analyses and services as well as weather forecasts and forecasting services, in order to promote wellbeing, safety, planning, economic development and adaptation to climate change. In Mozambique, a large portion of weather monitoring (especially rainfall) is done by the ARAs and, to a smaller degree, the Institute for Agrarian Research in the Ministry for Agriculture. As such, INAM provides technical assistance to institutions that carry out studies related to meteorology and promote the application of norms, terminology and standards in accordance with those established by the WMO. In 2012, INAM prepared a Strategic Plan (SP) for 2013 to 2017 with the technical support of the World Bank. The SP clarifies the mandate and objectives of INAM and outlines a road map for modernisation. On December 04, 2012, the Council of Ministers approved the SP for implementation.

C. International and Regional Collaboration

Through DNA, Mozambique participates actively in transboundary collaborations to improve the monitoring, management and exchange of hydrological data and forecasts across its shared river basins. The 2000 SADC Revised Protocol on Shared Watercourses enables Member States to exchange hydro-meteorological data for the purpose of cooperation, prevention and mitigation of the effects of floods. The General Principles (Article 3) of the Revised Protocol reiterate that "State Parties shall exchange available information and data regarding the hydrological, hydro geological, water quality, meteorological and environmental condition of shared watercourses". Mozambique is also a signatory of the Zambezi Watercourse Commission Agreement – ZAMCOM (signed 2004, ratified 2011). Under Article 15 of the Agreement, Member States have committed to providing readily available data; processing data that facilitates utilisation; employing standardised methodology on collection, processing and dissemination; co-operating in good faith; and providing data and information especially on hydrological matters and matters potentially harmful to people and the environment as circumstances permit[57]. Sharing data from the Zambezi River is also the specific objective through the MoU signed between Mozambique,

[57] To operationalise more effective management and sharing of hydro-met information in the Zambezi basin, in line with the legal transboundary agreements, international cooperating partners are preparing support to the ZAMCOM riparians and secretariat. The World Bank is actively supporting national level investments (as the basis of the bottom up information management system) and transboundary collaborations in the basin through the multi-donor trustfund Cooperation on International Waters in Africa (CIWA).

Zambia and Zimbabwe in July 2011 ("MoU for collaboration on information and data exchange in the management of catchment areas in the three countries in the Zambezi watercourse"). This MoU, in turn enables their Joint Technical Operational Committee to share hydrological forecasts between government agencies and dam operators in situations such as prior to the rainy season[58]. Other significant transboundary agreements with similar commitments include the 2002 Interim Tripartite Inco-Maputo Agreement and the 2002 Rovuma Agreement, among others.

6. Through INAM, Mozambique is an active member and signatory of international and regional initiatives that provide a platform for mutually beneficial collaborations. As a member of the WMO since 1976, Mozambique commits to promoting global meteorological and hydrological monitoring and forecasting by providing observations to the global network59 of observations. Mozambique is also member of the International Civil Aviation Organisation (ICAO), which has the authority to define, monitor and approve meteorological services and observations provided at international airports in accordance with WMO standards. Mozambique's National Aviation Authority selects INAM as the aviation weather services provider. INAM still needs to be ISO 9001 certified to serve aviation in line with ICAO rules. Mozambique participates actively in UNESCO's Intergovernmental Oceanographic Commission (IOC) activities, represented by the Institute for Hydrography and the Institute for Fisheries Research. The Maritime Administration and Safety Authority (SAFMAR) represent Mozambique in the International Maritime Organisation (IMO). IOC- and IMO-related activities generally also have a link to national hydro-meteorological services. INAM is also member of MASA (Meteorological Association of Southern Africa), whose constitution was signed May 11, 2009, and is associated with the African Centre of Meteorological Application for Development (ACMAD). Further, INAM is also a member of the SADC Drought Monitoring Centre (DMC), hosted by the Botswana Meteorological Service. INAM has signed a memorandum of understanding with the South African Weather Services (SAWS). The memorandum covers technical assistance, research and training, particularly in Numerical Weather Prediction.

D. Status of Observation Network

7. **Overall, only a third of Mozambique's collective network of hydrological and meteorological stations is operating and reporting data.** The ARAs primarily collect data on runoff and rainfall, but also discharge, groundwater and water quality parameters, though to a much lesser extent. Of the total ARA network, only 37% of runoff stations (fix-mounted staff gauges) and 25% of rainfall stations are reporting. Rehabilitation of existing stations is therefore a priority. ARA-Sul, for example, embarked on a network optimisation process under which the number of operational stations has tripled since 2004. The majority of the monitoring networks are manually operated through employing local Readers who take one rainfall reading and three

[58] A challenge to sharing of information is the divergence in models used among the riparians and dam operators (e.g., HCB uses a spreadsheet model for operation of Cahora Bassa, ZESCO uses MIKE for operation of the Kafue Gorge Upper Dam and Itezhi-Tezhi Dam complex, and ZRA uses HEC/Regression & Exponential equations).

[59] WMO's Global Telecommunication System (GTS) is the communications and data management component that allows the World Weather Watch (WWW) to operate through the collection and distribution of information critical to its processes. The Main Telecommunication Network (MTN), linking together three World Meteorological Centres (WMCs) (Melbourne, Moscow and Washington) and 15 Regional Telecommunication Hubs (RTHs) (Algiers, Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Jeddah, Nairobi, New Delhi, Offenbach, Toulouse, Prague, Sofia and Tokyo). The Regional Meteorological Telecommunication Networks (RMTNs) is an integrated network of circuits covering the six WMO regions. In southern Africa, the regional hub is in Pretoria in South Africa.

river stage readings per day (frequency increases during the rainy season). Telemetric systems have been installed in the Limpopo, Incomati and Zambezi basins that monitor basic parameters, store data in Data Collection Platforms (DCP) and transmit data either manually or through high frequency radio or GSM. However, success and longevity of these automatic systems is often hampered by the lack of consistency across technologies, access to equipment, financial resources and staff capacity.

8. Mozambique also has eight SADC-HYCOS stations installed (four on the Zambezi, two on the Púnguè and one each on the Incomati and Maputo rivers). However, DNA reports recurring challenges with the HYCOS stations, primarily either temporary station-specific interruptions to communications, or because the South Africa regional centre has not delivered web-based services as agreed. Only a small number of river stage monitoring stations are equipped with rating curves to transform water level into discharge. Current/velocity meters (both mechanical and Acoustic Doppler Current Profiler - ACDP) are insufficient, and in any case are not regularly calibrated. Rating curves are, however, developed using empirical equations calibrated and validated with infrequent profile measurements, making them less reliable, especially for high flows. Dynamic riverbeds subject to high rates of erosion, sedimentation and relocation further challenge both measurements and empirical analysis. The ARAs collaborate closely with the Cahora Bassa Hydropower operators (HCB, Hidroeléctrica de Cahora Bassa) as they measure dam outflow and operate a small number of rainfall and evaporation gauges. At the national level, there is a lack of systematic structure to the design of the network, yet certain stations that are strategically located (such as borders or confluences) report regularly. This is particularly true for ARA-Sul and ARA-Zambeze who have the strongest monitoring networks (reflecting greater levels of water dependencies, economic activity, commercial farming, population densities and dam infrastructures in the respective basins). The density of ARA's rainfall stations reporting is often higher than INAM's, which is the result of the ARAs having taken over operation of INAM's stations or due to the need to increase the ARAs' direct access to rainfall information.

9. INAM's meteorological observation network is characterised by low density of stations (many in need rehabilitation and calibration) and varying levels of technological solutions. Similarly to the ARAs, there has been no systematic design of the network and the location of stations match Provincial and District Level boundaries as well as strategic locations such as airports and parts of the coast. Mozambique has five automatic observation weather stations (AWOS, with hourly observation) for aviation at airports in the major cities still maintenance of Spanish TELVENT in 2011 showed that quality control and maintenance has undermined the quality of the AWOS. INAM's synoptic weather stations, 5 are automatic weather stations (AWS, with hourly observations) and 29 are manned stations (multiple parameters, hourly or 8 observations per day). The synoptic stations form the basis of INAM's aviation and general forecasts. Out of the 154 manned climatological stations (simple parameters, 1 or 3 observations per day) only 38 are operating due to lack of maintenance, financial resources and staff motivation. IIAM manage 14 manned agro-meteorological stations (3 observations per day) although the stations are technically part of INAM's network. The only upper-air monitoring equipment is two Doppler Radars in Xai Xai and Beira, built in 2006. They could approximate rainfall rates and accumulation areas as well as provide critical data input into Numerical Weather Prediction Models (NWP) and Early Warning Systems (EWS). However, neither are operating due to lack of staff and maintenance. The number of stations and the geographic extent of coverage of the network have declined significantly since the 1970s, and a large portion of

observation stations are defunct due to lack of maintenance, improper calibration, or inability to pay staff to collect data from the station. INAM is no longer able to afford upper air soundings and neither of the radar stations operate due to lack of maintenance. INAM has one access point for satellite/remote sensing data at their headquarters in Maputo. INAM has no observations systems for maritime meteorology. The National Institute for Hydro-geography and Navigation (INAHINA, Instituto Nacional de Hidrografia e Navegação) has 5 tidal stations, and some offshore buoys exist, but according to INAM, the buoys do not have instruments for measuring meteorological/oceanographic parameters and INAM has no access to these data. In the past, INAM used to supervise the rainfall monitoring done by other agencies (including the ARAs and the Ministry of Agriculture). Neither the enforcement of quality standards nor integration of their data is included in INAM's national precipitation database.

E. Data Management and Communication

10. It generally takes three months for hydrological data to move from the ARA readers to the national database in DNA. In the ARAs, readers submit paper records to the respective River Basin Unit (UGBs) office, which then enters the data into Excel. Excel files are sent on a variable weekly to monthly basis to the ARA headquarters, which subsequently pass on the files to DNA on a monthly basis. During the wet season (November to April), readers communicate directly with the ARA headquarters or DNA at certain important stations for flood forecasting and early warnings. The frequency of data transmission is, however, higher in ARA-Sul, where nine rainfall and river stage stations report daily, and in ARA-Zambeze, where information from key stations is emailed on a daily basis to DNA. High frequency radios, cell phones or email is used to transmit data from readers or UGB-offices in times of high flow. There is no established satellite data connection (for receiving or relay of data) and the GSM/GPRS signal has at times been irregular. Hydrological data is centralised at DNA using the HYDATA/HYDSTRA database, which was developed in 1995 by the UK Institute of Hydrology as one of the first available dedicated hydrological database packages. Although the HYDATA software has been upgraded to Windows since 1999, DNA still uses a 1995 DOS-based version. DNA and the ARAs are in the process of switching to the Windows-based HYDSTRA software, the original license of which is being provided by SADC as part of HYCOS Phase II. However, DNA is required to pay for six HYDSTRA licenses (one each for DNA and the five ARAs) currently costing RSA Rand 25,000. A major challenge with HYDATA is that once the ARAs have submitted data, they have little way of accessing it. ARA-Zambeze also employs the Temporal Analyst, although it appears to be run in parallel with HYDSTRA, with observation data being entered into both simultaneously. The national hydro-met database under their authority is not protected. The server hosting the data is neither backed-up or mirrored, and insecure in terms of access and viruses.

11. INAM has been able to introduce modern telecommunication system (*Messir*) in recent years. Internet linkages are established with Provincial capitals and leased lines connects Maputo with Beira and Xai-Xai (128 kbps), Maputo and Nampula airports (64 kbps) and the WMO regional GTS hub in Pretoria (64 kbps). A dedicated 2 MBps internet line was established in 2006 for downloading the boundary conditions for the PUM NWP model and a 512 kbps internet line is available for general use. However, the capacity of the internet connection does not allow collection of digital NWP products from international centres or quick processing of large sets of data. Furthermore, INAM regularly suffers internet failures. Data transmission from the few advanced observation stations is done using radio, email, SMS, and lately also with GPRS

(GPRS has increased the dataflow ability with more reliable connections to the automatic station and cheaper prices compared to SMS/text messaging technology). An MSG Satellite Receiver was installed in Maputo in March 2005 to access the EUMETSAT Data Collection Services (European Organisation for the Exploitation of Meteorological Satellites DCS). The DCS supports predictions by providing, for free, climate observations as well as a communication link to relay observation data. The data from manned synoptic stations is sent by radio, and from climate posts as hard copies by post or some person once per month. Data sent by radio is received at the INAM weather forecasting department where it is manually written down, yet the radio system for several stations is not reliable. Due to the poor communication system, human errors and other reasons, many observations recorded at the stations and posts never enter the central database in Maputo. The INAM meteorological digital database contains observations from 1908 to 2011. However, the data quality and temporal coverage are inconsistent. For example, due to missing calibration and maintenance resources, and lack of proper metadata, there are breaks in the time series. It would be possible to fill the gaps using the re-analyses data (ECMWF and NOAA) and high resolution NWP modelling. However, modelling several years at high resolution for a large country like Mozambique requires strong computing power and would require several months continuous running on a supercomputer. Currently the database has been down since April 2011.

F. Forecasting, Modelling and Information Products

12. DNA, ARA-Sul and ARA-Zambeze use limited hydrological forecasting, and only a few of their models are operational. Neither of the other ARAs use more sophisticated forms of flow forecasting. Over the past years, a number of different forecasting models have been developed and installed. In addition to the inconsistency associated with multiple models, other challenges included costs of software or ability to integrate with digital elevation models for more useful flood predictions. Overall, the lack of quality and real-time data, as well as location and quantity-specific rainfall forecasts, has affected all models. The availability of surveyed river cross-sections presents a challenge to proper flow forecasting and flood modelling. For example for the Zambezi River the last survey was in 2008, producing cross-sections every 25 km, while in the Limpopo the last survey was in 2005, also yielding cross-sections every 25 km. The frequency of surveys and limited resolution is insufficient for proper flood modelling.

13. ARA-Sul has separate GeoSFM models for the Limpopo, Incomati and Maputo River basins. These are still, however, based on the global data sets (HYDRO1k, etc.). More detailed river cross-sections have not been integrated into these models. These basin GeoSFM models also provide three-day flow forecasts, and are only put into operation during the rainy season. NOAA CPC daily rainfall estimates arrive with delay, resulting in the flood-forecasting model not being in real-time. Considering that CPC's daily rainfall estimates are produced about 18 hours past real-time, daily rainfall estimates are made available on FEWSNET for download with an almost one-day delay in Mozambique. These are also not calibrated with ground measurements. Input data is taken again from FEWSNET, to some degree augmented by ARA-Sul's own rainfall and river monitoring stations, as well as data from the South African Weather Service (downloaded from SAWS' website). ARA-Sul has developed flood inundation maps for three alert stages for the Limpopo, Incomati and Maputo Rivers. Alert stages are defined according to simple ranges of water levels. For example, in the Chokwé district within the Limpopo catchment, there are three stage categories. Level 1 is for 4 to 6m, 6-Level 2 is 8m, and Level 3 is 8 to 10 m. These levels have been developed through a GIS by overlaying observed river stages on a digital

elevation model (DEM) and computing flooded areas. For this purpose a 90m resolution DEM was developed based on digitised, colonial-era 1:50,000 scale topographic maps with 20m contours. This process was started after the 2000 and 2001 floods and only finished in 2009. During floods, ARA-Sul can provide information on potentially inundated areas by referring to these maps and comparing to river observations and forecasts. In the Limpopo River basin, the MIKE 11 is used as well as the WAFLEX spreadsheet-based model. The latter utilises a simple linear routing routine. WAFLEX has been developed for at least part of the Zimbabwean portion of the Limpopo River basin for dam management and water allocation with the support of WaterNet. But the Zimbabwean model is not linked to ARA-Sul's WAFLEX model. ARA-Sul also utilises the WEAP model. ARA-Zambeze operates a MIKE 11 unsteady 1-dimensional open-channel flow model upstream of the Cahora Bassa dam to the mouth of the Zambezi River for flood forecasting and water infrastructure operations, as well as FLOOD WATCH. Hydraulic routing is only performed on the main stem of the Zambezi, with tributaries modelled as hydrologic inflows. While the operators of Kariba Dam (the Zambezi River Authority) utilise HEC-RAS, HCB employs a spreadsheet-based model. ARA-Zambeze, despite operating MIKE 11, is unable to produce flood inundation maps owing to the fact that it does not possess a digital elevation model (DEM) of the Zambezi River basin. During 2007-2008 a full floodplain-coverage LiDAR high resolution DEM option was considered (total estimate at €900,000) as well as a joint cross-section survey augmented by site-specific LiDAR (total estimate at €300,000), but these were deemed too expensive. Acquisition of a DEM is considered a priority by the ARA-Zambeze technical team, although at the time of mission they were not aware of the freely available DEMs such as HYDRO1k and HydroSHEDS, produced from the Shuttle Radar Topography Mission (A Hydrologically-corrected DEM was produced from SRTM and is available through the USGS/WWF HydroSHEDS project at 3 arc-second resolution, corresponding to approximately 90 m). ARA-Centro Norte simulates rainfall-runoff processes on the Licungo River through a basic historical relationship.

14. DNA used to produce hydrologic yearbooks until the early 1970s. They have recently reintroduced this practice, starting with a summary book covering 1997-2010 and in 2010 a yearbook just for the Zambezi River. In 2011, DNA produced a yearbook covering both the Zambezi and Púnguè Rivers. Moving forward, more and more basins will be added to the yearbooks, although the agenda for this (and estimate year for complete national coverage) is not clear.

15. The ARAs produce daily regional hydro-bulletins during the flood season (Dec 1 – April 30), which includes up-to-date river stages and rainfall at key locations, but no forecasts. The bulletins are transmitted to DNA who merges them into a daily national bulletin for further national dissemination. At the regional level, the ARAs themselves disseminate the bulletins to the INGC regional offices, INAM provincial office, the RBUs, flood-prone district authorities, the Red Cross, NGOs and the local media. Only ARA-Sul produces a hydro bulleting during the non-flood season (May 1 – Nov 31). This "drought monitoring bulletin" is produced on a monthly or quarterly basis. DNA aims to initiate a national quarterly hydro bulletin for all times of the year. ARA-Sul also produces and disseminates a quarterly technical report, which includes an overview of hydro-met data collected, system improvements, reports and analyses of events and locations of interest, and progress on special projects and studies. A less technical annual summary report is also produced and disseminated. ARA-Zambeze provides rainfall and flow observations, as well as limited flood forecasts (maximum 3 day), to HCB free-of-charge. HCB reciprocates with outflow data and management plan information.

16. Neither DNA nor the ARAs regularly share data with INAM, even though the ARA rainfall monitoring network is far denser than INAM's. INAM does not have the HYDSTRA database which could lead to further limitations in data sharing, although this technical issue could easily be overcome. It does appear however that INAM sometimes (when they make a request) receives rainfall data from HCB. DNA and ARAs do not receive data or forecasts from INAM, either.

17. INAM undertakes a range of weather forecasts that vary both in spatial resolution, temporal resolution, and topic. INAM uses data from a range of sources, including its own observation network and remotely sensed data from other space and weather agencies. INAM's forecasts include:

- Seasonal rain forecasts during the rainy season. These forecasts are produced by the SADC regional Climate Service Centre, not INAM itself, and forecast whether precipitation is expected to be above, at, or below normal levels for each month. The forecasts are based on statistical inferences, not numerical models.
- 24-72 hour forecasts at the provincial level.
- 1-12 hour forecasts using EUMETSAT for the ten airport stations.
- Certain special-order forecasts by contract.
- Global graphical products. These are produced by the European weather forecasting center twice per day at a 16-km resolution. INAM also uses UK Metoffice data and NOAA/NCEP data.
- Regional forecasts with up to a five-day lead time are received from SAWS twice per day at 12-km resolution.
- Local area numerical model products.

18. The Aviation forecasting office located in Maputo produces the weather forecasts for flight levels using the global products from UK Metoffice, TAFs and aerodrome warning, sigmet/Airmet. Weather forecasts are produced for each airport four times per day based on regional NWP products (picture through Internet) from the South African Weather Services (SAWS), and ECMWF, NOAA and other global models. Currently there are problems with the communication systems, which cause problems in collecting observation data for Mozambique. INAM has some staff capacity to run its NWP models. These Local Area Models cannot be run operationally due to lack of adequate internet connection to download the boundary data. A Precipitation Atlas has been prepared with some difficulties, partly due to poor quality of precipitation data. INAM publishes seasonal rain outlooks for the months of October to December and of January to March. These are verified with the outlooks produced by the SADC regional Climate Service Centre located in Gaborone, Botswana. Outlooks seasons are produced using Statistical Seasonal Forecasting Methods (Simple Linear Regression). Since 2011, INAM started to introduce more complex statistical models and also numerical models (e.g. ECMWF, ECHAM) in the production of seasonal forecasting. At provincial level, general forecasts (24-72 hrs) are provided. Weather forecasting is based on the use of numerical weather forecasting model outputs received in paper map format, use of satellite images and data from the observation stations. INAM produces general weather forecasts for 24 hours and 72 hours. Forecasts are made for the three provinces (province-level resolution). INAM used to have a contract with the National TV to produce weather forecast in INAM´s studio and send it to the TV Company. The provision of this service stopped due to equipment problems. Currently INAM provides basic weather forecasts for no charge to the national and commercial TV channels, radio and newspapers.

Table 11. Overview of hydro-met information products

Hydro-Met Product	Input data & Content	Format & Frequency / Example of recipient
INAM		
Seasonal rain outlooks	Linear Regression; developed in conjunction with SARCOF, verified with SADC regional Climate Service Center outlooks. Precipitation (above, at, or below normal) for the major regions; sea surface temperature forecast (above, at, or below normal).	Hardcopy Monthly SARCOF, SADC
24-72 hour forecast	Numerical model outputs received in paper map, satellite imagery, and data from observation stations. Provincial / Temp, precip, relative humidity, wind speed and direction, air pressure, visibility.	Hardcopy
1-12 hour forecast	EUMETSAT imagery and METAR ("Nowcasting")	Hourly Airports, Aviation companies (including LAM)
Aviation weather forecasts	Relies on global products and outputs from other weather services	4x per day
Maritime navigation and meteorology bulletin	Visibility and cloud cover; wave heights; wind speed (50 miles off coast)	
Maritime navigation and meteorology bulleting	Visibility and cloud cover; wave heights; wind speed (Mozambique Channel)	
Cyclones: ad hoc monitoring	Receives bulletins and imagery every 30 minutes from Le Reunion when cyclones are present	Ad hoc
Special order forecasts	INAM provides customised forecasts and sells available historical records on an ad-hoc basis	Ad hoc Private sector
Special order data products	INAM provides assorted historical records in response to unique request upon agreed payment.	
10-day agricultural bulletin	Description of rainfall and temperature patterns with historical patterns; rainfall screen capture; summary of satellite rainfall data; seasonal climate prediction	
Precipitation Atlas	Planned, but not completed.	
DNA		
National hydrological bulletin	National - Flow and precip observations at key locations, dam outflows, some forecasted flows and indication of proximity to critical flows	Hardcopy Daily during rainy season
Regional bulletins	Bulletins based on ARA regions	
International Hydrological Bulletin	Summary of hydro-met situation; status of major dams (24 hour mean discharge, level, % filling); forecast; selected river levels and precip. registered and illustrative graphics;	Hardcopy Daily during rainy season SADC, ZAMCOM, LIMCOM, PRIIMA, RSA, CapNet, Zambia, Zimbabwe, Malawi, Botswana, Swaziland, HCB, ZRA, WWF
ARAs (ARA-Sul, ARA-Zambeze)		
Daily hydrological bulletin	River stages, rainfall at key locations	Hardcopy DNA, INGC (informally), HCB
RBUs daily bulletin	River stages, rainfall at key locations	Daily
ARA-Sul targeting Quarterly technical report	Overview of hydro-met data collected, system improvements, reports and analysis of events	

G. Human Resources and Staff Capacity

19. In Mozambique, the cadre of trained meteorologists and hydrologists is limited, and government salaries are generally considered to be low in comparison to what the growing private sector or international jobs can offer a university/technically-trained person. Retention of qualified staff is a serious challenge across all hydro-met agencies. Education opportunities for hydro-met are often abroad, although there are collaborative efforts between government and experts at the University of Eduardo Mondlane in Maputo on expanding the training opportunities within Mozambique (at present, UoEM only offers meteorology training to the level of BSc).

20. In DNA, the Hydrologic Information Management Unit coordinates national hydrologic observations. The unit consists of twelve technical staff. ARA-Sul currently employs 522 people of varying qualifications and skills (of which 213 are Readers). This is somewhat below the target staffing of 608 as determined by ARA-Sul's 2003 Business Plan. ARA-Sul's Headquarters Technical Department is small but skilled. The number of staff for the remaining ARAs drop drastically: 149 at ARA-Centro (of which 78 are Readers), 145 in ARA-Zambeze (of which 115 are Readers), 29 in ARA-Centro Norte (with 26 Readers) and 39 in ARA-Norte (with 28 Readers).

21. The total staff number of INAM is 230. Overall, the staff has quite good academic training: in 2005 the number staff with research education (PhD, Lic.) was 5; currently, there is one PhD, two PhDs in progress, and about 40 staff with Licentiate degree. However, the majority of staff are observers, which is striking in comparison to more advanced NHMSs where observers have been replaced by automatic weather stations. INAM has 20 forecasters in all. Of these, 13 forecasters are partly working at the headquarters of INAM and partly at the Maputo Airport. Five forecasters are doing public weather forecasting. Two meteorologists are running NWP models (not currently operational), and they also help the other forecasters to interpret NWP products and specific phenomena. Typically, staff at main synoptic stations (provincial centres) comprises one administrative meteorologist and a varying number of observers. At the provincial level, the running costs of INAM's stations and staff at the manned stations, posts and aviation offices are paid by each province. These costs are not included into the INAM's budget.

H. Financial Sustainability

22. The primary sources of revenue for INAM, DNA and the ARAs are the government budget and donor funding. In addition, INAM sells custom data products, the ARAs collect revenue from bulk water sales, and ARA-Zambeze receives US$ 250,000 annually from Hidroelectrica Cahora Bassa. Some of the ARAs also obtain revenue from renting property or charging fees for recreational use of property. In general, is has been difficult to aggregate information on both revenues and expenditures due to different reporting standards and unconsolidated records. It is not clear that there is a consistent structure for recording expenditures. Moreover, only ARA-Sul was able to provide data on property and accounts payable. Most of the ARAs report that they are unable to afford the legally required annual audits that would provide such information in a consistent, reliable format.

23. Sectoral funding fluctuates both over time and across the agencies. When looking at funding sources across all organisations (Table 12 and Table 13), it is apparent that donor funding has constituted the largest source of revenue for all but one year and that revenue from sales

consistently provides the least revenue. With the exception of 2009, government funding to the entire sector has increased between 2007 and 2012. Despite providing the greatest quantity of revenue, donor funding is also the most variable between years, increasing, for example, from US$8 to 80 million between 2007 and 2008 (a 900% increase), then dropping to US$45 million in 2010.

24. High variation in funding across organisations is apparent from the data presented in Table 12 and 13. DNA has received more revenue than all other agencies combined in every year for which there is data. ARA-Centro Norte has received the least, although this is partly explained by the fact that it was only established within the last four years. Among the ARAs, ARA-Sul consistently receives the greatest amount of funding, which likely reflects it role in supplying water to Maputo and the extensive infrastructure it manages. ARA-Sul is also able to derive over one-third of revenue from sales of bulk water.

25. The demand for water resources and hydro-climatic information is growing in Mozambique but many agencies have been caught in a trap: without sufficient funding to establish robust consumption monitoring or information delivery programs, they are unable to generate sustainable revenue flows despite the likely presence of unexploited consumer surplus. Consider, for example, that the aviation sector is one of the greatest potential customers for INAM, but INAM receives less than 3% of its budget from the aviation sector. Cahora Bassa dam has an installed capacity of 2,075 MW but HCB pays only US$250,000 annually to ARA-Zambeze for use of the Zambezi's water resources. Although the ARAs receive revenue from bulk water sales, they have difficulty monitoring consumption. Few commercial services are produced for, e.g. the media, which is a very different situation compared to European NHMSs. There is significant potential to further develop the production and sale of commercial sale of water and weather-information products; the political economy of the hydro-met sector has, however, limited the exploration of these opportunities and subsequently harms the sector's sustainability.

Table 12. Water sector revenue 2007 to 2012 (US$)

	2007		2008		2009		2010		2011		2012	
	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
ARA-Sul												
Total	**5,391,012**	100	**8,430,614**	100	**8,305,720**	100	**8,800,538**	100	**11,038,147**	100	**9,953,990**	100
Sale of bulk water	1,995,770	37	2,547,164	30	2,818,434	34	3,433,103	39	3,722,992	34	3,825,556	38
Gov't subsidy	2,694,157	50	4,915,232	58	4,485,363	54	4,251,691	48	6,089,883	55	5,116,801	51
External donors	-	-	128,324	2	138,914	2	199,595	2	-	-	-	-
Other	701,085	13	839,894	10	863,009	10	916,149	10	1,225,273	11	1,011,632	10
ARA-Centro												
Total	**317,963**	100	**117,786**	100	**2,388,613**	100	**124,612**	100	**487,475**	100	**84,440**	100
Sale of bulk water	-	-	85,675	73	63,936	3	114,448	92	145,832	30	82	
Gov't subsidy	317,963	100	1,120	1	1,082	0.05	713	1	339,415	70	49,811	59
External donors	-	-	30,991	-	2,323,596	97	9,452	8	2,228	0.5	34,547	41
ARA-Zambeze												
Total	**2,575,207**	100	**1,611,346**	100	**514,808**	100	**594,976**	100	**656,628**	100	**777,739**	100
Sale of bulk water	59,614	2	72,260	4	61,389	12	61,218	10	88,316	13	102,703	13
Gov't subsidy	250,089	10	149,753	9	211,392	41	234,618	39	301,060	46	407,784	52
HCB	234,324	9	220,000	14	242,027	47	299,141	50	267,252	41	267,252	34
External donors	2,031,180	79	1,169,334	73	-	-	-	-	-	-	-	-
ARA-Centro Norte												
Total	-	-	-	-	-	-	**3**	100	**598**	100	**352**	100

Sale of bulk water	-		-		-		-		185	31	27	8
Gov't subsidy	-		-		-		-		411	69	324	92
External donors	-		-		-		-		-	-	-	-
Other	-		-		-		3	100	2	0.4	1	0.2
ARA-Norte												
Total	**-**		**8,186**	100	**9,666**	100	**12,888**	100	**17,751**	100	**3,908**	100
Sale of bulk water	-		8,186	100	9,666	100	12,888	100	17,751	100	3,908	100
DNA (millions $)												
Total	**11.3**	**100**	84.3	**100**	79.6	**100**	55.0	**100**	78.6	**100**	55.5	**100**
Gov't subsidy	6.1	54	6.4	8	6.1	8	10.6	19	6.9	9	11.5	21
External donors	5.2	46	78.0	92	73.5	92	44.3	81	71.6	91	44.0	79

NB: Dollar amount converted from Metical at the rate of 27.7 MT per US$1. Empty rows indicate missing data. "Other" under total revenue for all ARAs includes ARA-Zambeze's revenue from HCB. ARA Centro-Norte was created in 2010; ARA Norte was created in 2009. Other missing data was not reported.

Table 13. INAM revenue 2007 to 2012 (millions of US$)

	2007		2008		2009		2010		2011		2012	
	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
Gov't	0.66	46	0.79	39	0.96	57	1.05	72	1.42	73	1.74	83
Donors	0.78	54	1.23	61	0.72	43	0.41	28	0.01	0	--	--
Sales	--	--	--	--	--	--	--	--	0.52	27	0.37	17
Total	**1.44**	**100**	**2.02**	**100**	**1.68**	**100**	**1.45**	**100**	**1.94**	**100**	**2.10**	**100**

Note: Dollar figures converted from Metical at the rate of 27.7 Metical per US$1.

Table 14. Revenue sources aggregated across INAM, ARAs and DNA (millions of US$)

	2007		2008		2009		2010		2011		2012	
	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
Gov't	10.01	48	12.24	13	11.74	13	16.17	25	15.07	16	18.79	27
Donor	8.04	38	80.51	83	76.73	83	44.94	68	71.63	77	44.02	64
Sales/tariffs	2.29	11	2.93	3	3.20	3	3.92	6	4.76	5	4.57	7
Other	0.70	3	0.84	1	0.86	1	0.92	1	1.23	1	1.01	1
Total	**21.04**	**100**	**96.52**	**100**	**92.53**	**100**	**65.94**	**100**	**92.69**	**100**	**68.38**	**100**

Note: "Sales/tariffs" includes revenue from HCB, bulk water sales, and other revenues from sales to INAM.

Table 15. Total revenue by organisation (millions of US$)

	2007		2008		2009		2010		2011		2012	
Organisation	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
INAM	1.44	6.84	2.02	2.10	1.68	1.82	1.45	2.20	1.94	2.09	2.10	3.08
DNA	11.32	53.79	84.33	87.37	79.63	86.06	54.96	83.34	78.55	84.75	55.46	81.10
ARA-Sul	5.39	25.62	8.43	8.73	8.31	8.98	8.80	13.35	11.04	11.91	9.95	14.56
ARA-Centro	0.32	1.51	0.12	0.12	2.39	2.58	0.12	0.19	0.49	0.53	0.08	0.12
ARA-Zambeze	2.58	12.24	1.61	1.67	0.51	0.56	0.59	0.90	0.66	0.71	0.78	1.14
ARA-Centro Norte							<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ARA-Norte			0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.00	0.01
Total	**21.04**	**100**	**96.52**	**100**	**92.53**	**100**	**65.94**	**100**	**92.69**	**100**	**68.38**	**100**

I. Disaster Management and Hydro-Met Services

26. As Africa's third country most-at-risk of extreme water and weather events, Mozambique regularly suffers the effects of floods, droughts, storms and cyclones. In January 2012, Mozambique faced two tropical storms in a single week – storm Dando and cyclone Funso – affecting 33,500 households, destroying 5,000 houses and causing the loss of 6,000ha of agricultural crop. An estimated US$17 million was required for humanitarian aid and disaster recovery measures. In 2013, floods in southern Mozambique were caused by extreme rainfall in the upper catchment of the Limpopo River Basin in Zimbabwe and South Africa. The flood levels in the river's lower stretches near Chokwé in Mozambique were equal to those of the floods of 2000. Although the flood peak was rapid and the high levels receded faster than in 2000, the flood resulted in a humanitarian crisis and widespread destruction to infrastructure, agriculture and housing. The total cost is yet to be determined, but over 90 lives were lost and over 200,000 people were displaced.

27. The institutional mandates and mechanisms for disaster management in Mozambique are comparatively well established and effective in the region. The National Institute for Disaster Management (INGC, Instituto Nacional de Gestão de Calamidades) coordinates directly with DNA and INAM. DNA (ARAs) and INAM provide INGC with daily bulletins (via fax and email). A persistent challenge for INGC is that the hydro-met information provided is not accurate enough, nor sufficiently scaled to specific areas/locations or provided with lead-times that would allow INGC to mobilise response activities earlier. There is presently no data-sharing platform that is connected to multiple streams of data or more real-time data.

28. At the highest level, decisions are made through the coordinating body – CCGC – which is chaired by the President or Prime Minister and attended by all the sector ministers. This grouping is where major decisions are made regarding disasters and announcing states of emergency. At the technical/operational level the CTGC convene depending on the level of alert, and, where relevant, ministries and departments participate. During a disaster, the emergency operational committee mechanism at provincial level is activated (COE). A situation room is established in INGC where all technical representatives of INAM, ARAs and other stakeholders are represented. All information passes through this grouping and decisions are made by the team. Meeting frequency and attendees depends on the alert levels (yellow or red). In case of red alert, the provincial governor chairs the meeting and the committee meets every day.

29. At the provincial level, the INGC Committee gathers representatives from multiple stakeholders, including INAM and ARA, and in turn coordinates with District Risk Management Units and Local Risk Management Committees. During normal alert periods, INGC makes use of the River Basin Committees (RBC) set up by the ARAs to engage other stakeholders in disaster preparedness. During RBC meetings, INAM presents the forecast of the season and the ARAs present forecasted models for the season, taking into account water level observations and historical water level and rainfall observations. INGC uses this information to develop contingency plan for the basin.

30. Vertical communication between local and national levels is strong, in accordance with INGC's protocol. At the time of floods, alerts at the local level are communicated through a system of colored flags. Communities are also equipped with bicycles to move from one place to another to disseminate information. High-frequency radio is commonly used to communicate directly to INGC at the provincial level in case of emergency. However, parallel communications

between the ARAs and INAM at the local level is not strong – despite informal efforts to collaborate.

ANNEX 9: TEAM COMPOSITION

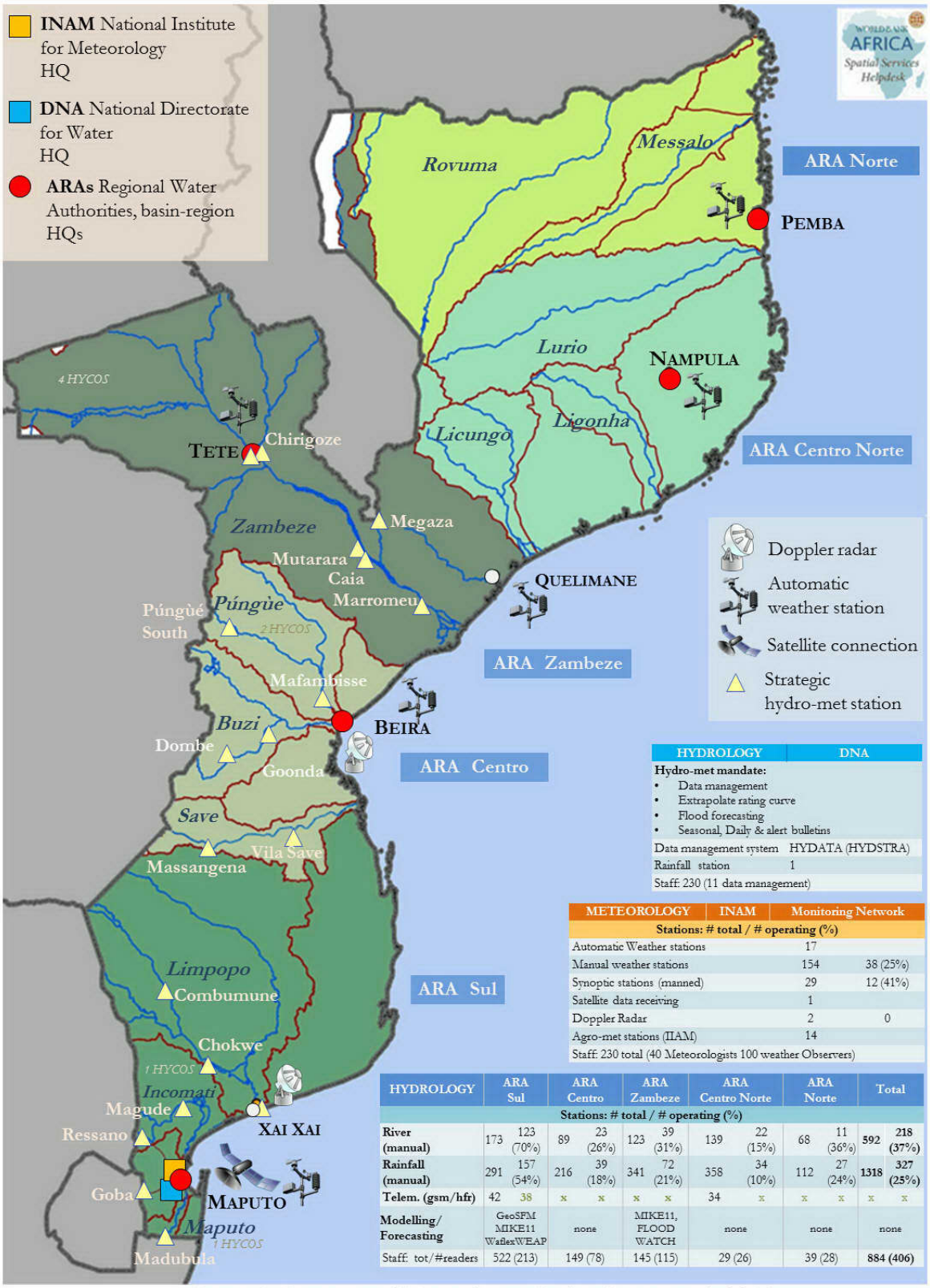
Mozambique Climate Resilience: Transforming Hydro-Meteorological Services Project

World Bank staff and consultants who worked on the project		
Name	*Title*	*Unit*
Marcus Wishart	Sr Water Resources Specialist, TTL	AFTN2
Louise Croneborg	Water Resources Management Specialist, Co-TTL	AFTN2
Eric Foster-Moore	Operations Analyst	AFTN2
Celia dos Santos Faias	Team Assistant	AFCS2
Bengt Tammellin	Sr Meteorologist	Consultant/AFTN2
Daniel Kull	Sr Hydrologist/Disaster Risk Specialist	GFDRR - WCIDS
Vladimir Tsirkunov	Sr Environmental Engineer	GFDRR - WCIDS
Francis S. Nkoka	Disaster Risk and Climate Change Specialist	AFTN2
Jeff Lazo	Sr Economist	Consultant/AFTN2
Hrishikesh Patel	GIS Specialist	AFTN1
George Ledec	Lead Environment Specialist	AFTN3
Kristine Schwebach	Sr Social Specialist	AFTCS
Rafael Saute	Communication Specialist	AFRSC
Ross Hughes	Sr Climate Change Specialist	AFTN1
Sofia Bettencourt	Lead Operations Officer	AFTN2
Roberto White	Sr Disaster Risk Specialist	Consultant/AFTN2
Antonio Chamuco	Sr Procurement Specialist	AFTPC
João Tinga	Financial Management Specialist	AFTFM
Jose Janeiro	Sr Finance Officer	CTRLA
Luz Meza-Bartrina	Sr Counsel	LEGAM
Mohammad Nadeem	Legal Analyst	LEGAM
Ivo Imparato	Sector Leader	AFTSN

Government of Mozambique staff who worked on the project		
Name	**Position**	**Organisation**
Suzana Saranga Loforte	National Director	DNA
Helio Banze	Deputy National Director	DNA
Luis De Almeida	Project Coordinator	DNA (PAMT)
Ronaldo Inguane	M&E Officer	DNA (PAMT)
Almiro Souto	Procurement Specialist	DNA (PAMT)
Antonio Nhampossa	Financial Specialist	DNA (PAMT)
Carla Machatine	Team Assistant	DNA (PAMT)
Rute Nhamucho	Head of Department	DNA-DRH
Ana Fotine Mponda	Technician	DNA-DRH
Egídio Govate	Geologist/ Technician	DNA-DRH
Lily Nomboro	Technician	DNA-DRH
Lucas Chairuca	Technician	DNA-DRH
Luisa Da Conceicao	Technician	DNA-DRH
Jose Frederico Pereira	Technician	DNA-DRH
Elias Massicame	Cooperation officer	DNA-DRH
Jose Malanco	Head of Information Management Section	DNA/DRH
Bernardino David Novele	Head of Department/Hydraulic Works	DNA-DOH
Andre Davis Zibia	Technician	DNA-DOH
Hilario Pereira	Technician	DNA-DRI
Daude Carimo	Director	DNA-GIPSA
Jaime R. Mianga	Pmu/Gipsa	DNA-GIPSA

Justino Marrengula	Technician	DNA-DGRA
Pedro Gambulo	Sr Engineer	DNA/DRI
Rogerio Batine	Technician	DNA
Alcino Luis Nhacume	Technician	DNA-DAR
Arlindo Correia	Technician	DNA-DAS
Moises Vicente Benessene	National Director	INAM
Atanasio Manhique	National Deputy Director	INAM
Brizito Jose Francisco	Delegado Regional Centro Norte	INAM - Nampula
Francisco Nostado	Meteorologist, Chief of Admin Department	INAM
Anacleto Duvane	Meteorologist/Head of Research Department	INAM
Daniel Macaringue	Meteorologist	INAM
Goncalves Junior	Meteorologist	INAM
Jose Sequeira	Meteorologist	INAM
Xavier Agostinho Chavana	PPCR National Focal Point	MPD
Guilhermina Amurane	PPCR Co-Focal Point	MICOA
Belarminio Chivambo	Director General	ARA-SUL
Delario Jose Sengo	Head of Technical Department	ARA-SUL
Lizete Días	Technician	ARA-SUL
Edmundo Vilanculos	Technician	ARA-SUL
Gimo Macaringue	Technician	ARA-SUL
Lino Quissico	Technician	ARA-SUL
Calisto Mabote	Director	ARA-SUL UGBI
Eurico Macuacua	Head of Wr Services	ARA-SUL UGBI
Antonio Wate	Technician	ARA-SUL UGBI
Bernabe Alexandre Fondo	Technician	ARA-SUL UGBI
Henrique Rosa	Technician – Communications Officer	ARA-SUL UGBI
Custodio Vicente	Director	ARA-ZAMBEZE
Manuel Afonso Malaze	Hydrologist	ARA-ZAMBEZE
Cacilda Machava	Director General	ARA-CENTRO
Rui Manuel Soares Fonseca	PNDRH-Activity Coordinator	ARA-CENTRO
Joaquim V. Langa	Director	ARA-CENTRO NORTE
Pascoal Alfredo Mucache	Head of Technical Department/Hidrometrista	ARA-CENTRO NORTE
Inogencio Escova	Hydrologist	ARA-CENTRO NORTE
Victor Mmacinco	Geographer	ARA-CENTRO NORTE
Joao Tiago Ribeiro	General Director	INGC
Suzie Aly	Soil Fertility Researcher	IIAM
Tomas Maculuve	Head of Agricultural Water Management Division	IIAM
Paulo Benzane	Technician	IIAM-DARN
Luís Tobela	Head of Department for International Cooperation	MPD
Edison dos Santos F. Días	Technician/Officer	Banco do Moçambique
Amélia Cardoso	Technician/Officer	Ministry of Finance
Teresa M.A. Langa	Head of Department	Int Cooperation, MOPH

ANNEX 10: MAPS & ILLUSTRATIONS



HYDROLOGY	DNA
Hydro-met mandate:	
• Data management	
• Extrapolate rating curve	
• Flood forecasting	
• Seasonal, Daily & alert bulletins	
Data management system	HYDATA (HYDSTRA)
Rainfall station	1
Staff: 230 (11 data management)	

METEOROLOGY	INAM	Monitoring Network
Stations: # total / # operating (%)		
Automatic Weather stations	17	
Manual weather stations	154	38 (25%)
Synoptic stations (manned)	29	12 (41%)
Satellite data receiving	1	
Doppler Radar	2	0
Agro-met stations (IIAM)	14	
Staff: 230 total (40 Meteorologists 100 weather Observers)		

HYDROLOGY	ARA Sul		ARA Centro		ARA Zambeze		ARA Centro Norte		ARA Norte		Total	
Stations: # total / # operating (%)												
River (manual)	173	123 (70%)	89	23 (26%)	123	39 (31%)	139	22 (15%)	68	11 (36%)	**592**	**218 (37%)**
Rainfall (manual)	291	157 (54%)	216	39 (18%)	341	72 (21%)	358	34 (10%)	112	27 (24%)	**1318**	**327 (25%)**
Telem. (gsm/hft)	42	38	x	x	x	x	34	x	x	x	x	x
Modelling/ Forecasting	GeoSFM MIKE11 WaflexWEAP		none		MIKE11, FLOOD WATCH		none		none		none	
Staff: tot/#readers	522 (213)		149 (78)		145 (115)		29 (26)		39 (28)		**884 (406)**	

Figure 4. Overview of Mozambique Hydro-Met network 2012

Mozambique : Average Annual Precipitation

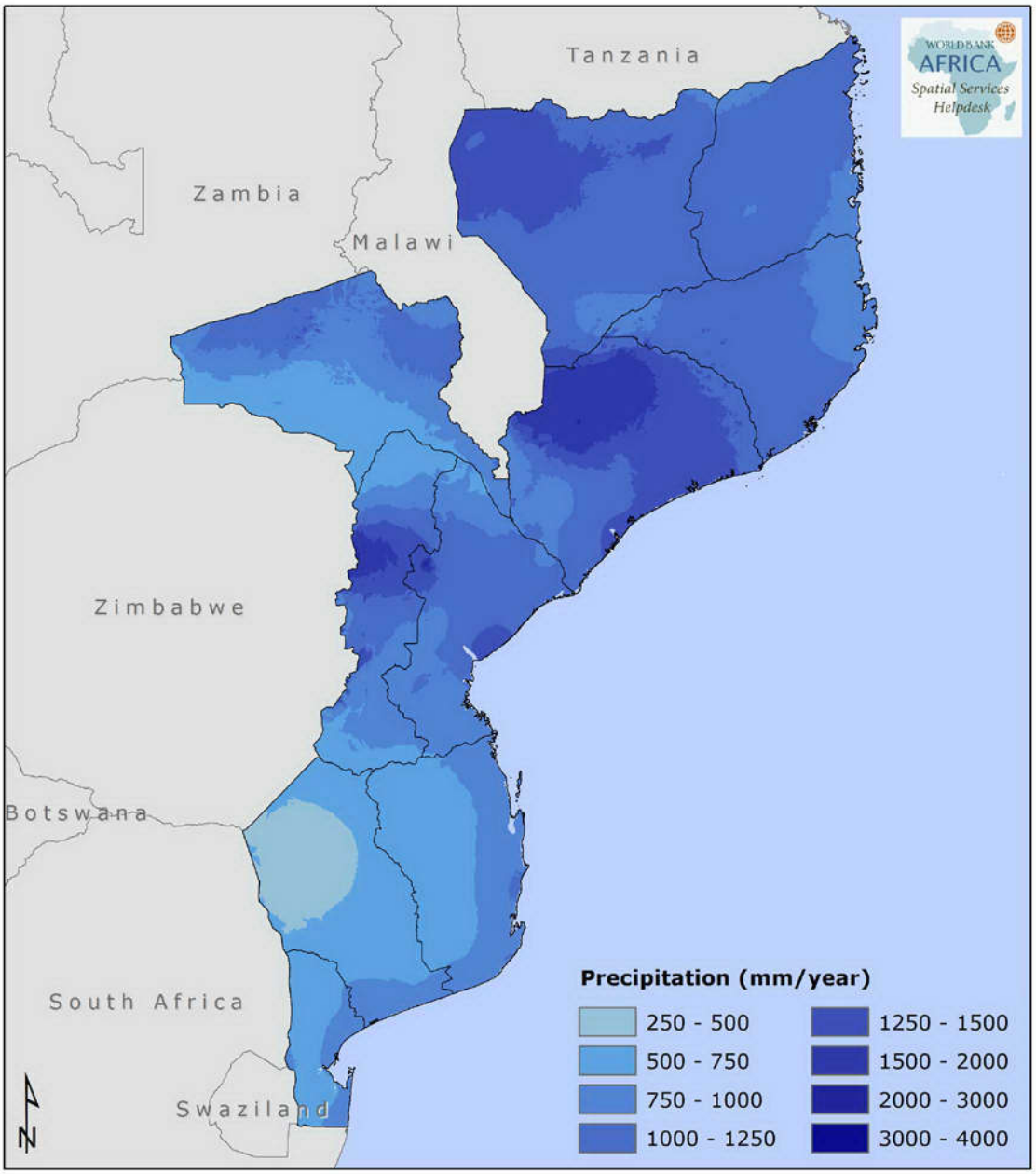
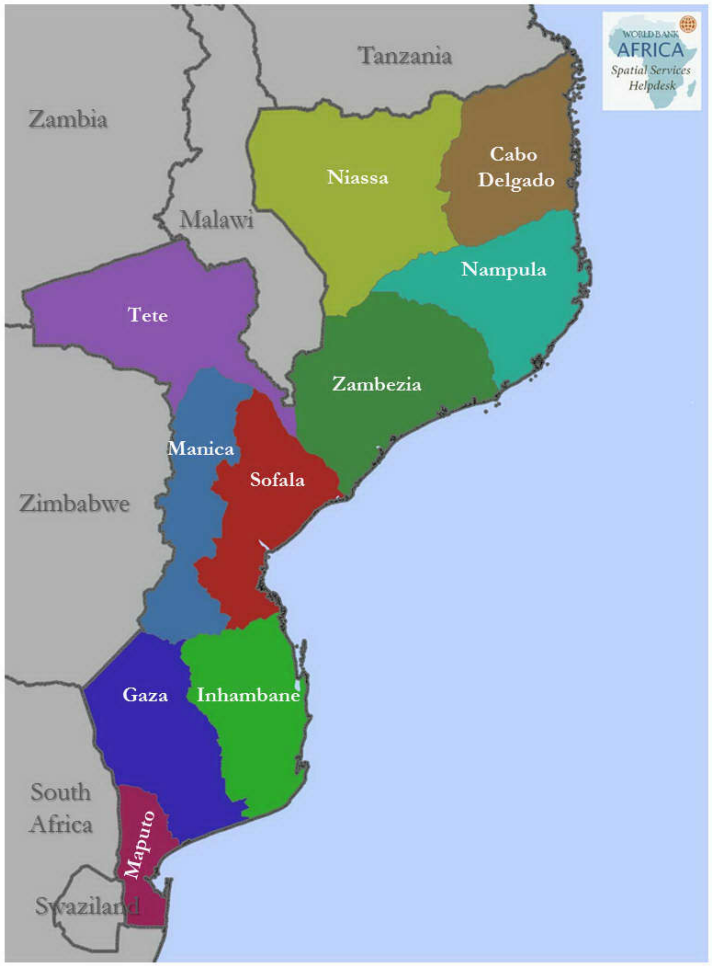
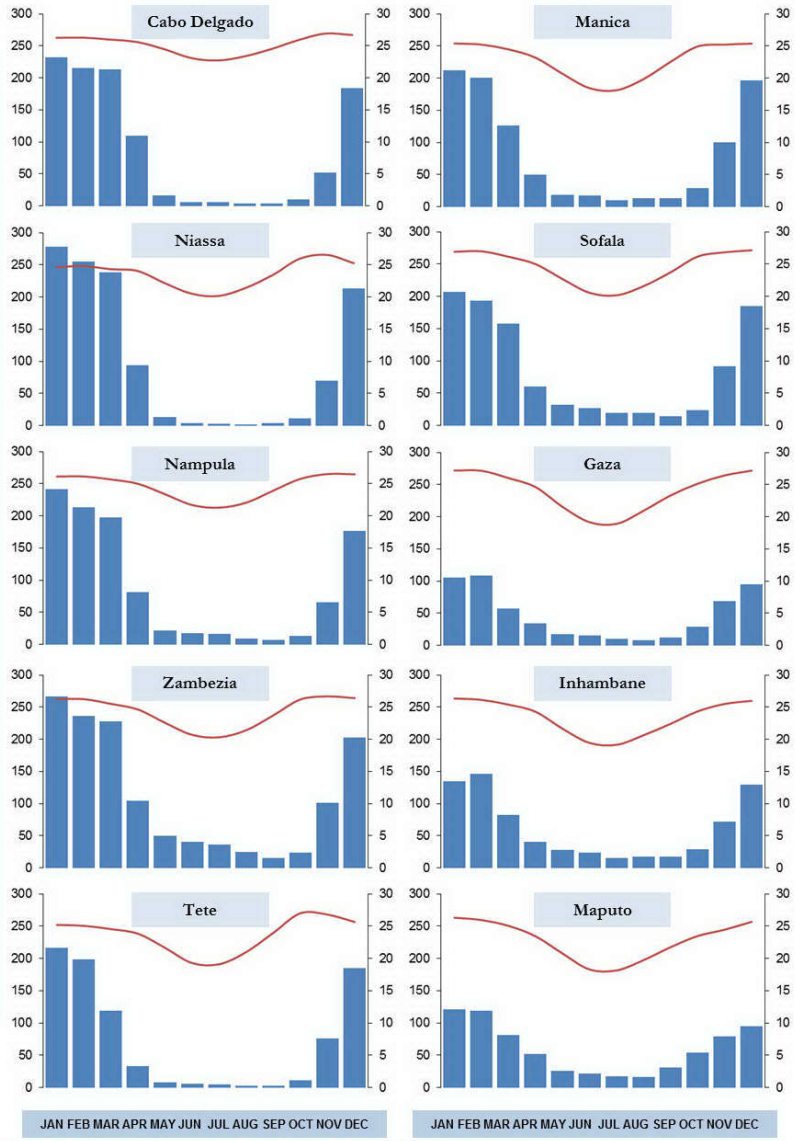


Figure 5. Average rainfall distribution (mm/yr)

Mozambique: Regional Intra-Annual Climate





Precipitation (mm)

Temperature (Celsius)

Figure 6. Inter-annual Rainfall and Temperature at Provincial level

Mozambique: Vulnerability from Storms

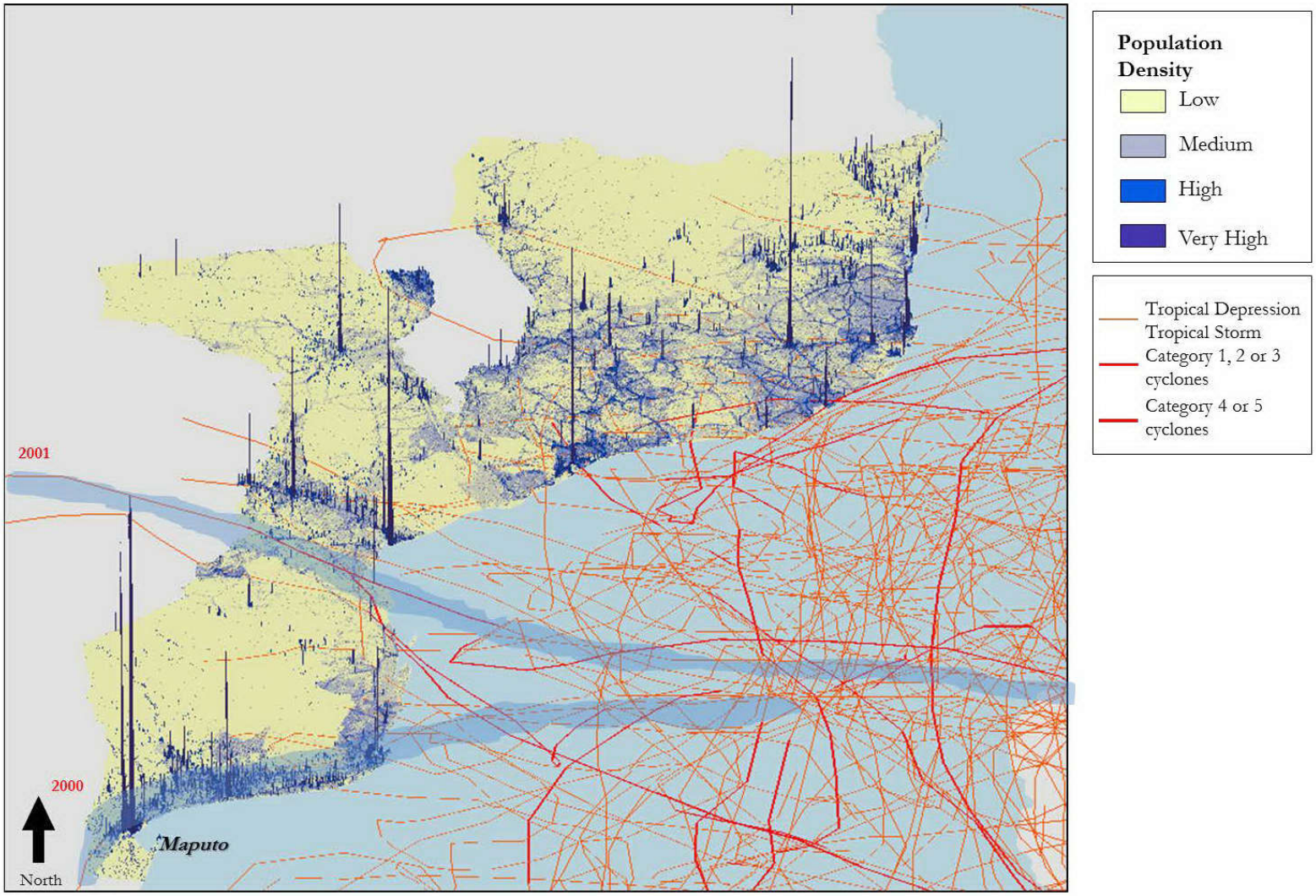


Figure 7. Population density; tropical storm and cyclone paths

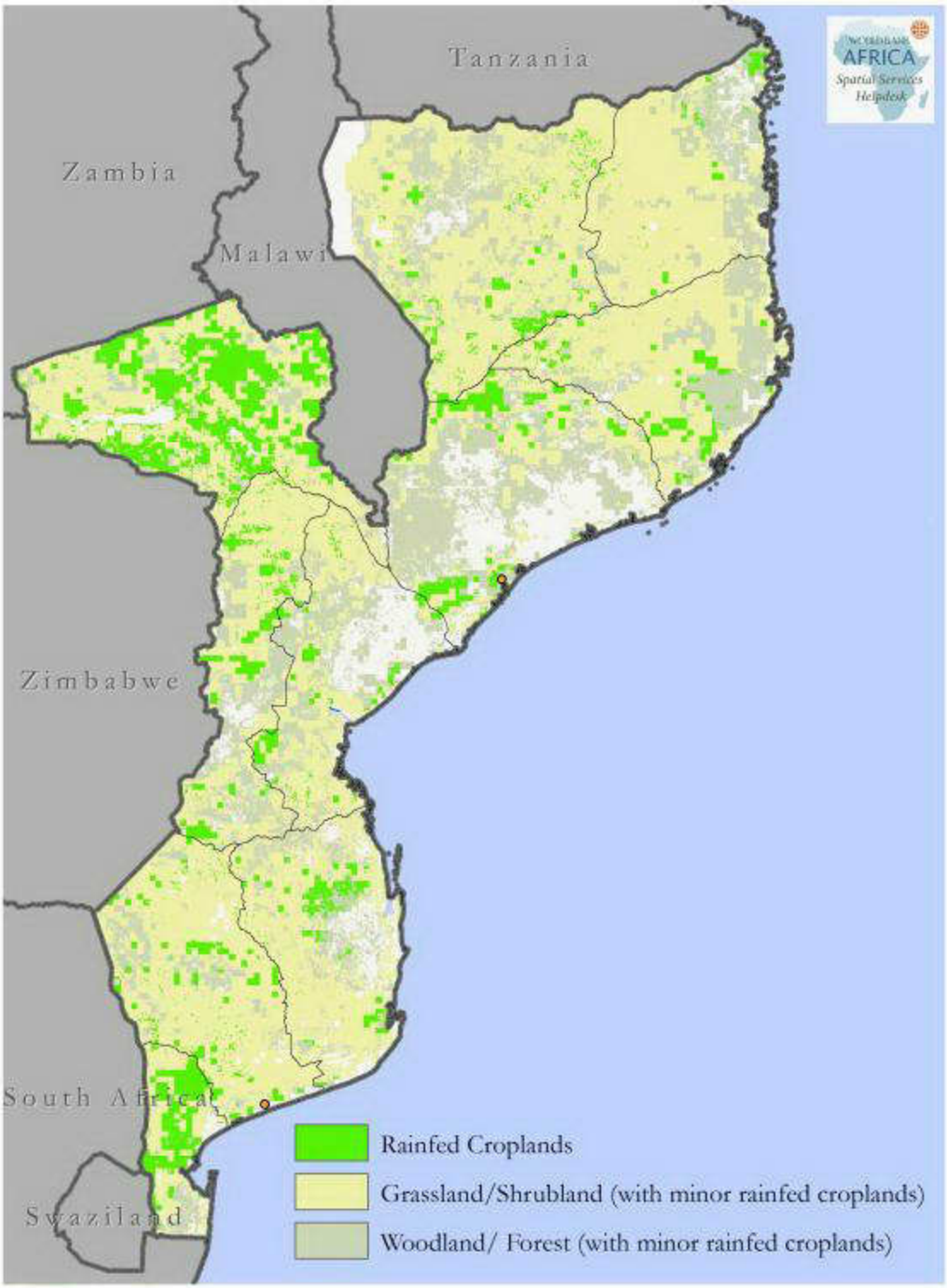


Figure 8. Distribution of rainfed croplands, grassland and woodland.

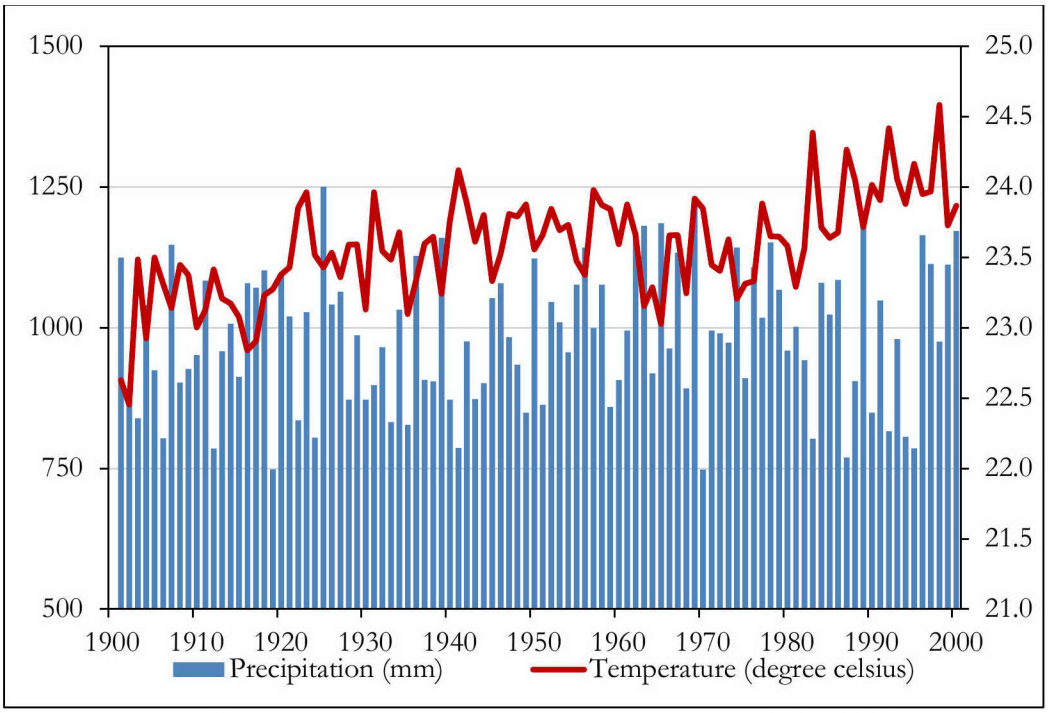


Figure 9. Inter-Annual climatic variability in Mozambique (1900 – 2000)

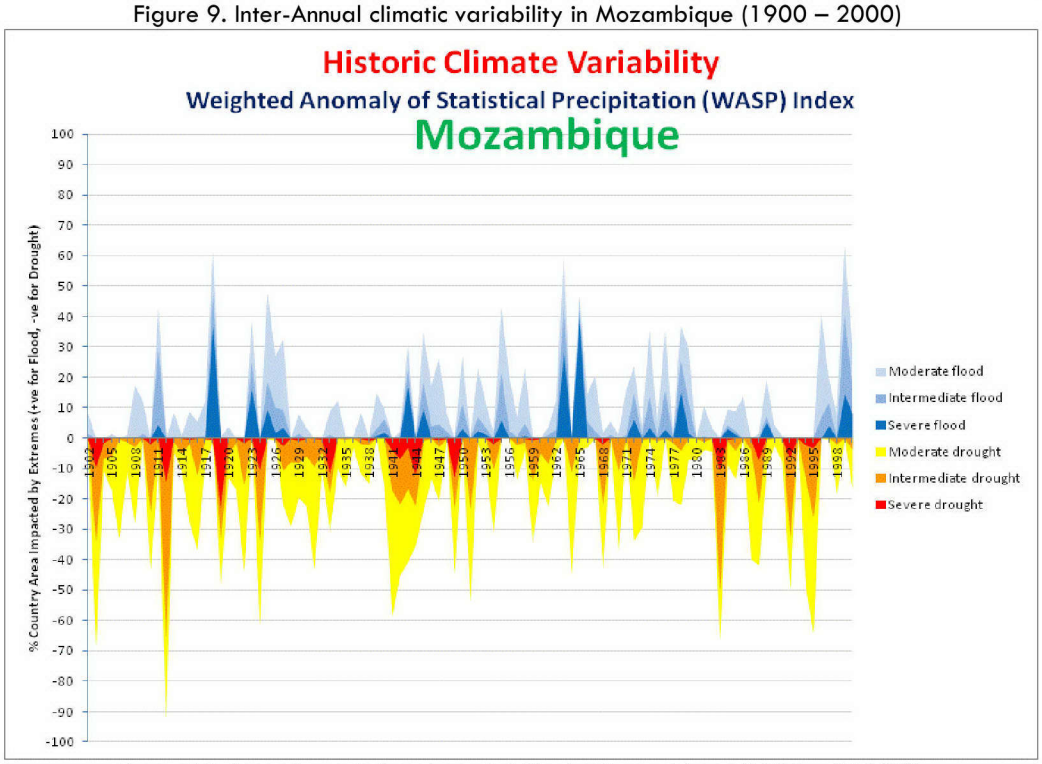


Figure 10. Inter-Annual climatic variability in Mozambique (1902 – 2000)[60]

[60] The yellow-red markations (drought) show percentage of country's area that would experience lower than normal rainfall (to different degrees). Equally, the blue markation indicate higher than normal rainfall and exten show precentage of country's area. Source: IRI Columbia University derived from the CRUT-S (Climate Research Unit at East Anglia UK).