



ESTABLISHMENT OF FLOOD EARLY WARNING SYSTEM IN NIGERIA

The Federal Ministry of Environment
(Department of Erosion, Flood and Coastal Zone Management)

in collaboration with

United Nations Development Programme



Final Report
by

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**ESTABLISHMENT OF
FLOOD EARLY WARNING SYSTEM
IN NIGERIA**

**DEVELOPED BY
FEDERAL MINISTRY OF ENVIRONMENT
ABUJA**

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ACKNOWLEDGEMENTS

In this changing world when our environment is facing the increasing challenge of flooding due to climate change and other conditions such as land use change and rapid urbanisation, the need for the establishment of a flood early warning system for Nigeria cannot be overemphasised. Since the creation of the Federal Ministry of Environment in 1999 by the administration of Chief Olusegun Obasanjo, the interest of the Federal Government of Nigeria in meeting environmental challenges have increased significantly.

My utmost gratitude to the United Nations Development Programme (UNDP) for funding the establishment of flood early warning system is boundless. The collaboration with the Federal Ministry of Environment in organizing a National Workshop on Flood Early Warning Systems (FEWS) and sponsoring Working Group Meetings held in Abuja opened up all avenues for the success of this initiative.

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PREFACE

Flood hazards are becoming persistently occurring in almost all parts of Nigeria. Although flooding is a natural and certain phenomenon which generally results in damage to property and negative impacts on human welfare, floodplain management is the process of minimizing property damage and reducing the threat to human life and welfare when major storms occur.

In Nigeria, the basic causes of floods are heavy and intense rainfall associated with high run-off. Other causes of floods in the country include dam breaks, blockages in river channels, population pressure as increasing number of people, especially the poor, are settling in flood-prone areas. In addition, some land use practices, some of which tend to favour increased runoff and decreased infiltration of rainfall into the soils, contribute significantly to the increasing trend of flooding in the country.

Since the incidence of floods are caused by many factors, not only those restricted to hydro-meteorological phenomena, the successful operation of an Flood Early Warning System in Nigeria demands an Integrated Flood Management Approach, whereby all related organizations from all sectors of the country should be involved. This report includes the design of the integrated management approach which incorporates all the designated agencies and parastatal in the country having to do with flood monitoring, management and emergency response.

The great losses sustained from flood damage annually constitute great problem in flood management and environmental sustainability. This is because coordinated attentions in terms of flood monitoring and prediction have not been given priority to address the menace of these increasing problems. In addition, physical vulnerabilities: poverty, severe over-population and unregulated human activities are major factors contributing to the country's vulnerability to flood disasters.

Having noted the huge economic losses from floods nationwide, and poised to adopt a proactive preventive approach in the management of flood, the Federal Ministry of Environment collaborated with the United Nations Development Programme (UNDP) to organize a National Workshop on Flood Early Warning Systems (FEWS) to create awareness on its importance and work out modalities for the establishment and implementation of FEWS in the country.

The Workshop noted that the impacts of damaging floods occasioned by Climate Change and other human activities can be reduced by strengthening disaster preparedness capabilities of relevant Institutions, and therefore resolved among other things to effectively combat the effect of Climate Change for sustainable development, food security and the well-being of Nigerians. The establishment of Flood Early Warning System (FEWS) was therefore concluded to be a priority project of the Federal Government of Nigeria.

This report has provided guidelines which when carefully followed will minimize the occurrence of flood hazards and the need for costly flood control measures and the aftermath expenses of flood disaster. The recommendations herein should therefore aid in the appropriate establishment of FEWS in Nigeria.

EXECUTIVE SUMMARY

CHAPTER ONE

For the establishment and operation of the proposed FEWS to be successful, the contribution and coordination of diverse range of relevant institutions, agencies, communities and individuals are required. These stakeholders have specific functions, roles and responsibilities for which they are accountable in the successful operation of the proposed FEWS. Following a bottom-up approach, these stakeholders include: vulnerable communities resident in the eight hydrological areas of the country; Community Based Organizations; Local, State and Federal Governments of Nigeria; Government Agencies and Institutions; the Private Sector, the Academic and Scientific Community; Non Governmental Organizations; Regional Institutions and Organizations; and International Organizations.

The concept of Flood Early Warning Systems (FEWS) and its application as a flood disaster reduction strategy is at its inception stage in Nigeria. Hitherto, the key components of FEWS such as data collection and transmission, flood forecasting, warning dissemination and communication, and emergency response were carried out by different agencies and institutions which operated independently in standalone mode. There is no coordinated monitoring of floods or established early warning systems for flood disaster reduction in Nigeria. Majority of the river systems in Nigeria do not have functional water level gages while those rivers that have stage and discharge stations are not integrated into a coordinated system. The status of hydrometeorology data collection and monitoring for flood early warning is grossly inadequate in majority of the river basins in the country.

CHAPTER TWO

The National Workshop on Flood Early Warning System (FEWS) held at Reiz Continental Hotel in Abuja between Tuesday 5th and Wednesday 6th of August 2008, cover wide ranging topics like: the causes of floods; the management of flood disasters; role of NGOs, CBOs and other stakeholders in the management of floods; socio-economic consequences of floods; capacity building for Flood Early Warning Systems.

The Workshop was divided into four (4) different Technical Sessions with a total of twelve paper presentations. The Workshop deliberated on twelve (12) papers presented by seasoned resource persons. All the twelve papers were reviewed.

CHAPTER THREE

The framework of early warning systems consists of three phases including the monitoring of precursors, forecasting of a probable event, and the notification of a warning or an alert should an event of catastrophic proportions take place. Since the incidence of floods in the country are caused by several factors including hydro-meteorological phenomena, the successful operation of an Early Warning System in Nigeria would require an Integrated Flood Management Approach, whereby all related organizations from all sectors of the country should be involved.

Flood Early Warning System (FEWS) is an integrated package of data collection and transmission equipment, forecasting models, response plans and procedures, and human resources working together with the sole objective of empowering individuals and communities threatened by flood hazard to act in sufficient time and in an appropriated manner to reduce the possibility of personal injury, loss of life and damage to property and the environment. FEWS in Nigeria has been designed to be people-centred and integrate Knowledge of the risks faced by the society; Technical monitoring and warning services; Dissemination of meaningful warning to people at risk; and Public awareness and preparedness to act.

The design incorporates approaches employed for design and operation of Flood Early Warning Systems in the Haddington FEWS in the UK; Norwegian FEWS; and Japan's FEWS and the Flood detection and early warning systems developed in Malaysia which includes a public alert system for possible imminent flood events. The FEWS design for Nigeria focuses on monitoring the water level remotely using wired sensor network. Data is collected from the sensor using data acquisition device and channelled to the National FEWS Centre which relay the information to the public through Global System for Mobile Communication (GSM) using Short Message Service (SMS). The system ensures that the end users receive appropriate warning within suitable time interval to take effective action to save lives and minimize loss of properties.

Longer lead times and improved accuracy of flood forecasts require an effective use of the latest technology available in the fields of hydrology and meteorology as well as Information, Communication and Technology (ICT). The best design option for Nigeria's FEWS is for an integration of flood forecasting and early warning services that is people-centred in focus.

CHAPTER FOUR

The primary goal of this guideline is to work out modalities for the establishment and operation of Flood Early Warning Systems in Nigeria. To effectively achieve this goal the objectives of this guideline shall be to work out modalities to: Reduce the risks of flood disasters on vulnerable communities of Nigeria and thereby save lives and properties; For the establishment of FEWS as a non structural strategy for flood disaster reduction in Nigeria aimed at minimizing the damage of flood water in flood prone areas of Nigeria; and Establish an effective, integrated, cost effective and sustainable Flood Early Warning System that is institutionally manageable and technologically sound and flexible.

Among the technical challenges in the establishment of an integrated and coordinated Flood Early Warning Systems in Nigeria includes: Availability of hydrological and meteorological data; Diverse topography and geology; Sediment loading problems in river systems and its effects on long term operation of the FEWS; Changes to channel geometry variability; Adaptation of the FEWS for the diverse types of flooding experienced in Nigeria; and Willingness of the Telecommunications service providers to participate in the establishment and operation of the FEWS without unreasonable financial motivations that will kill the system right from inception.

Some institutional challenges to the establishment and operation of FEWS in Nigeria include: Inadequacy in existing institutional capacities and the bureaucratic tendencies of the institutions to interoperability highly essential for timely data sharing and dissemination which is the heart of the FEWS; Inadequate flood hazard assessments capability; Effective monitoring and evaluation of the Flood Early Warning Systems; Cooperation between Government agencies; Private sector involvement; Community ownership and interest; Financial sustainability; and Economic incentives.

CHAPTER FIVE

Since Flood Early Warning Systems begin with data collection and transmission. Rainfall is to be measured with automatic rain recording gauge which will record the time at which a known volume occurs. From this time series, the rate of and cumulative depth of rainfall can be calculated. The river level (in case of the river flood plain) and/or the tidal level (in case of the coastal flood areas) are to be monitored using simple automatic recording sensor mechanism without direct contact with the water surface. However, real-time precipitation data from satellite sources would be employed in monitoring and forecasting rainfall using remote sensing. In order to increase the lead time, rain forecasts would be derived from statistics. Wireless data-transmission would be used for online transmission of both the data measured and those obtained from satellite sources.

The major characteristics of rainfall that affect the amount and rate of runoff which are important for this Flood Early Warning System (FEWS) model includes: intensity; depth; distribution over an area (spatial); and, distribution over time (temporal). There are a number of physical characteristics of catchments that affect the amount and/or rate of runoff they generate. Some of these characteristics vary with the season and the type of management practices used. The impact of an individual characteristic depends on the size and shape of the catchment.

Due to the importance of having a simple, reliable and cost effective system, the Flood Early Warning System Model is to be based primarily on the characteristics of rainstorms likely to cause floods. Such characteristics of importance includes extreme meteorological event in form of approaching rain bearing storms of tropical cyclone, rainfall intensity/amount indices, and the anticipated water levels of river channels.

The typical model entails the observation and prediction of flood stage. However, the lack of existing reliable hydro-meteorological data creates difficulties in establishing empirical relations which could directly be employed in developing a scheme. Hence, an isolated event model approach which employs information on rainfall characteristics and its routing through a linear reservoir is prescribed with analysis of the catchment response. The model assumes that runoff occurs as predicted by the contributing area theory which requires that all the rain falling on the saturated portion of the catchment will create runoff but no runoff will occur immediately from the remainder.

The National FEWS Centre would issue storm summaries on storm systems bringing significant rainfall to portions of Nigeria. Using the information obtained from satellites, quantitative precipitation forecasts are to be prepared and forecasts of accumulating (quantitative) precipitation, heavy rain, and highlights of areas with the potential for flash flooding, are to be issued with forecasts valid over the following five days. These products are to be archived and made available on the Internet for public use. Heavy rain forecast, in association with the short-range public forecasts would serve as a coordinating mechanism for the National FEWS Centre's watch and warning program.

The National FEWS Centre is to be responsible to the Presidency, however, through the Federal Ministry of Environment. River Basin Base Stations are to be established at catchment level with each having a minimum of three (3) Out Stations located at different distances apart in a manner to cover at least the upper, middle and lower reaches of the rivers. Each River Basin Base Station is to be equipped with adequate infrastructure to receive information from the Out Stations and effectively relay the same in real-time to the National FEWS Coordinating Centre. The Out Stations are primarily to be a stand-alone river gauging unit equipped with adequate capacity to collect and relay both runoff and rainfall data on a regular interval of 60 to 180 minutes. This information are to guide in the Flood Early Warning System's decision process and as well form the eventual database for the derivation of empirical relations required for the development of rainfall-runoff and flow routing models specific to particular catchments.

The FEWS model described is primarily based on storms expectation from satellite forecast rainfall due to the lack of existing information on rainfall and runoff which could be adequate for flood early warning system design. It however, incorporates a fully automated system of data acquisition which is expected to take off as soon as possible to ensure an itch-free system.

While flash flooding is assumed to be the major issue in the urban areas, the flood stage conditions downstream the floodplain (i.e. varied catchment conditions e.g. slope and geology, varied drainage and flow routing systems) and in the coastal areas (i.e. tidal level, earthquake conditions, flow routing from fresh water reservoirs upstream e.t.c.) are considered multi-dimensionally.

The model is expected to become fully operational as soon as possible while model calibration and program algorithm are deliberately delayed because of the lack of real-time information (including rainfall, runoff, soil condition/storage, catchment characteristics e.t.c.) required to develop location specific empirical relations which are to be based on the theoretical relations already provided in the model. However, it is hoped that hypothetical data based on field specific observations shall be employed for simulation in order to perform the model demonstration.

CHAPTER SIX

Most of the equipments to be employed in the Flood Early Warning System are stand alone automatic devices. This is necessary in order to reduce the human resources required to man measuring outstations from where rainfall and runoff information are accumulated. The primary equipments to be used are Stand Alone Automatic Rainfall Recorder; Radar Level Gauge/Recorder; and Automatic Data Logger/Transmitter. All of these are recommended to be sourced from SUTRON CORPORATION, which is a registered ISO 9001:2000 company, not a third party, and provides engineers, designs and manufactures equipments in the USA. The Sutron Corporation is preferred not only because their equipments are well automated alone but also because it delivers the fastest direct, responsive after-sales support, repairs, and replacements for as long as their equipment is in operation.

The estimate cost of the vital equipments required as obtained from Sutron Corporation in the United States of America, the manufacturers of most of the products recommended for use in Nigeria is \$ 14,282 (=N= 2,142,300) for one outstation and \$ 35,000 (=N= 5,250,000) for a basin station as well as all installations and maintenance charges. The sum total cost required for all the equipment is \$ 49,282 (=N= 7,392,300). Letter of Credit on International Bank acceptable to Sutron, phased payments based on delivery and acceptance criteria and the freight terms to be determined based on actual order-plan on 4 to 5% of equipment total. Project will however, require six to nine months, minimum.

CHAPTER SEVEN

The most effective and efficient means of data and information sharing in a Flood Early Warning System is through an automated system

which requires little human input or influence. The proposed employment of automated (auto-recording) stand alone state-of-the-earth equipments for data collection, accumulation and transmission for the Flood Warning System in Nigeria will ensure a reliable system.

While the equipments are to collect and record the rainfall and water level in amounts, the data logger keeps consistent recordings which also are transmitted through the link to satellite sources, to the base station from where the data is further transferred to the National FEWS Coordination Centre where the data is processed and utilized for decision purposes. The transmission from the Base station to the National FEWS Centre is to be made through the designated web-based portal for flood forecasting and management system. This web-based system which is dependent on the internet forms a ready and reliable route of data transmission due to its long range of reach and the capacity to manage a network of information stream from multiple sources. The web-based system also makes it possible to monitor and predict events from both the existing and prevailing information on a point pattern basis.

Due to the less developed condition of information dissemination in the country, the existing Short Message Services SMS provided by the GSM telecommunication industry would be broadly utilized for information dissemination. Although, the automated equipments would send data collected to the base station via transmitters, the messages containing data from the gauging stations in the community-based flood early warning system which involves local volunteers will also make use of the Short Message Services. It is very convenient for the local volunteer who probably must have been used to sending messages to friends and relations using the GSM mobile phone before, to send code-like messages directly to the hotline of the National FEWS Coordinating Centre.

Furthermore, aside from the web-based code messages which would consist of data from the different outstations serving the base station, which would be sent through email, the base station which is to be manned by at least and ad-hoc or permanent staff, would also communicate with the National FEWS Coordinating Centre via the GSM Short Message Services SMS.

However, it is incumbent on the National FEWS Coordinating Centre to provide the web-based portal through which the flow of information is to be done in a more centralised and coordinated manner. Another

reason why this is important is the present global trend of Information Communication Technology development which Nigeria has already bought into as a country. The web-based system makes it easy to follow the process from the level of forecast, monitoring and warning.

The mass media (both the print and electronic) would also play a major role in informing the populace most especially through radio programmes targeted at carrying the local communities with little or no access to ICT, along. Television programming and special forecast and interactive programmes of enlightenment would also improve the knowledge of the members of the communities with access to televisions who would in turn explain the tips and details to friends and relations. The records of storm and the character of flood as well as what to do in case of flood emergency would all form the basis of enlightenment campaign on the television and radio in the form of paid advertorials and advertisements.

Information sharing would also be done by the use of billboards which would help in instructing the members of the community on how the processes involved are. Billboards located in the centres of the community where most inhabitants pass through would be quite a sight. While local materials such as wooden boards and planks may be relevant in the rural areas, large electronic advert boards which would display different information ranging from flood data, forecast and instructions, may be fashionable for the urban areas and the cities particularly prone to flood risks.

However, the broadcasting corporations including the radio and the television stations have a lot of work to do in the area of early warning communication. As soon as the flood forecast indicates an impending flood, the National FEWS Coordinating Centre informs the Ministry of Information and Communication which would in turn charge its affiliate broadcasting organisations with the responsibility to inform and alert the communities with the impending flood risk. The evacuation plans and the necessary emergency rescue instructions would also be passed across through this media.

But due to the emergency situation particularly in abrupt and severe cases when it may not be possible for the affected communities to tune in to the radio and television, when even the sources of power supply might have been damaged, the onus lies greatly on the local volunteers and emergency rescue operatives to be responsible for the rest of the action needs for information. This again is another reason why local

volunteers must be very well incorporated into the flood early warning system. In fact, it may not be out of place to relate to and consider the local volunteers as ad-hoc staff members of the National FEWS Coordinating Centre, which would serve as a motivation and means of encouragement to foster dedication and commitment.

Another very important early warning modality is again, through the Short Message Services of the GSM mobile telecommunication providers. As this is among the fastest growing and most subscribed industry in Nigeria, the flood early warning communication can be done through alert messages which is sent as cautionary instructions to all subscribers. Due to the magnitude of the responsibility of government to secure the lives and properties of the citizenry, it is necessary to strike a deal with these telecommunication providers to participate in this early warning alert exercise.

CHAPTER EIGHT

The technical and scientific capacity requirements for the establishment and operation of FEWS in Nigeria shall include: Identification of technical staff and training options in the areas of hydrology, meteorology, and flood forecasting and hydro-meteorological data collection. It also entails the identifying, planning and implementation of capacity building programmes involving technical training for meteorologist, hydrologists, hydrological forecasters, ICT professionals and database administrators such that their knowledge of monitoring devices, forecasting, communication and telemetry options, emergency response, community awareness and education is improved.

The design, review and updating of the training programmes to provide staff at different levels with advanced technology required to meet the challenges of hydro-meteorology data collection and transmission, flood forecasting, sustainable FEWS development and operation in Nigeria is also important.

Training on hydrologic data collection, transmission, achieving and retrieval techniques, methods of communication interface techniques between meteorological inputs and hydrological models and advantages and weaknesses of radar applications in Flood Early Warning Systems operations; Training on the analysis of the catchment characteristics of a specific river basin and the rainfall-runoff response of the basin to precipitation inputs and flood forecasting are necessary for effective running of the system.

Establishment of the process and opportunities for staff training and continuous education; as well as establishment of the process for FEWS staff secondments to FEWS installations in developed countries for the purpose of capacity development of such individual; and the consistent engagement of FEWS technical staff in pilot demonstrations or projects to support capacity building and education opportunities in flood forecasting and other relevant FEWS related areas are also pertinent.

The institutional capacity building initiatives relevant for the establishment and operation of FEWS in Nigeria are strategic national legislation and policy formulation training courses developed to enhance the ability of the Federal Ministry of Environment's capacity to motivate government to put in place the institutional and legal basis for the establishment and continuous funding and implementation of Flood Early Warning System in Nigeria.

Overseas study tour to established and operating FEWS installations, especially Sutron Corporation FEWS installations in developing and developed country designed to enhance the knowledge base of key representatives of relevant institutions involved in the establishment and operation of FEWS in Nigeria;

FEWS monitoring and evaluation training programmes designed to enhance the capacities of all organizations and institutions involved in the establishment and operation of FEWS to assess FEWS performance and develop capacity building plans and training programmes to ensure the sustainability of the system; Awareness and training programmes for political lobbying strategies for accessing government funding at national, regional and international levels for the FEWS establishment and operation in Nigeria;

High level consultation and workshops converging technocrats, politicians, government officials, academic and research institutions, and private sector operators should be established for awareness development on the benefits and relevance of FEWS establishment and operation in the hydrological areas of Nigeria for the consolidation of the millennium development goals.

CHAPTER NINE

The requisite content of a community-based Flood Early Warning System for Nigeria include well motivated, instructed and equipped local volunteers; network of rainfall and water level stations; flood stage

assessment levels; threshold value for rainfall observation with a value chart or graph as an index for flood potential; database source for future strategies; a set of community actions based on rainfall and water level observation; : a set of actions are to be based on the flood monitoring observations.

These actions are sign communicated using action indicators. These actions which are simple, pragmatic and task specific such that the operations are meaningfully achievable within the context of the community-based FEWS include: Level 1 (READY) which is indicated by the green colour and is triggered immediately a rain storm commences; Level 2 (GET SET) which is indicated by the amber colour and is triggered when a certain rainfall threshold or flood stage level is attained; and Level 3 (GO) which is indicated by the red colour and is triggered within a specified length of time after the rainfall threshold or flood stage level has been attained.

The actionable scheme of the community-based flood early warning system begins with the identification, training and equipping of the local volunteer who plays a very vital role in the entire scheme. The local volunteer is to act and operate as the remote ad-hoc personnel of the National FEWS Centre since most of the flood early warning activity in that particular community is hinged on him/her. The training is expected to be short and simple one that would be done in a matter of a day or two at most. The training is to be only practical without necessarily bearing much on the theoretical issues of flood and early warning system.

The equipments required for the efficient functioning of the local volunteer on whom the training is to be based are: Transistor radio, Mobile (GSM) phone, Rain-gauge, Water level staff-gauge, Log-book, Action indicator, and Megaphone load-speaker.

CHAPTER TEN

The proposed automated Flood Early Warning System for Nigeria is simple and achievable, its immediate establishment is recommended. The equipments and infrastructural requirements prescribed are to be procured urgently. A fully functional web-based flood forecasting and management system is to be developed as proposed.

All identified institutions are to be charged to brace up to the challenge of their full participation in the establishment and operation of the flood early warning system in Nigeria. Selected members of staff in the Federal Ministry of Environment, particularly in the Erosion Flood and Coastal Zone Management unit, are to undergo proper thorough training in order to build the requisite capacity to establish and operate the proposed Flood Early Warning System for Nigeria.

The Federal Government of Nigeria should as a matter of necessity declare flood early warning system as a priority project and ensure the smooth take off and development of the Flood Early Warning System which is proposed in this report while the Federal Ministry of Environment in conjunction with the Federal Ministry of Information and Communication are to continue awareness campaign toward evolving the consciousness of the general populace on the establishment of the Flood Early Warning System in Nigeria, and all that pertains to it.