Strengthening Community Resilience to Climate-induced disasters in the Dili to Ainaro Road Development Corridor, Timor-Leste.

Deliverable 3: Design of a model EWS and SOPs that can be tested in four sub-districts within the DARDC region.

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1. Introduction

In this document the design of a community-based early warning system (CBEWS) for four communities in the Dili-Ainaro road corridor will be presented, as well as requirements at the national level needed for the functioning of an Early Warning System (EWS). There are several requirements regarding the design of these systems. Four different type of hazards should be addressed, namely floods (flash-floods), landslides, strong winds and fires. Also, the implementation of these four CBEWS should at least cover 5000 households.

2. Background

The Dili-Ainaro Road Development Corridor project, is aimed at strengthening the resilience of communities living in the Dili-Ainaro Road Development Corridor to climate-induced disasters such as floods and landslides and to reduce the risk of damage to road infrastructure. An essential component of this project is the development and testing of an Early Warning System in the Dili-to-Ainaro Road Development Corridor. Early warning systems (EWSs) are an essential and cost-effective component of disaster preparedness and response strategies. In Timor-Leste, EWSs are in a preliminary phase of implementation. A model EWS will be developed. This model will be tailored to the conditions facing rural communities in Timor-Leste.

3. EWS Model

Four different hazards have to be addressed within this EWS model at four different locations within the project study area. Further consultations will be held to decide if the EWS in each location should focus on one or more hazards and if the preselected target communities are best suited for the project.

The consultant visited with a UNDP and NDOC team the study area in order to have a closer look at rural conditions, visit communities where disasters have occurred, have meetings with District Administrators and District NDOC Focal Points and to possibly identify the four different locations for the design of the EWS.

The following locations and type of EWS have been initially selected:

- Ainaro Village: Strong Wind and Fire EWS
- Aituto Village: Landslide and Strong Wind EWS
- Aissirimou Village: Flood and Fire EWS

- Cassa Village: Strong Wind, Fire and Flood EWS.

The location and assigned EWS are not final, and it is open to discussion and changes. The model EWS presented for each hazard below can be implemented in alternative locations with relative easiness. Just one location per hazard will be selected for illustration purposes. The work-plan and budget will be detailed for all the different hazards and locations.

Regarding the general approach, it should be noted that due to the nature of the hazards, a simple community-based approach is not always sufficient. The support of organisations at national level is required, and therefore the system will be explained at both community and national levels.

In the following sections, each of the type of EWS will be described following the four components approach (risk assessment, monitoring and warning, communication and dissemination and response). This approach is used in order to ensure that all the different aspects required for a EWS to work are put in place. If any of these four components fails, the whole system fails. It should be noted that in some cases some of the EWS components will be the same for all the different hazards, namely the risk management and especially the communication and response components.

4. Flash-Floods / Floods

As an initial approach, two types of flood can be identified in the study area in, namely flash floods and riverine floods. The type of flood is very important because it will dictate the approach regarding the EWS.

Flash Floods

A flash flood is generally defined as a rapid onset flood of short duration with a relatively high peak discharge. A combination of a high rainfall rate with rapid and often efficient runoff production processes is common to most flash flood events.

These floods are frequently associated with violent convection storms of a short duration falling over a small area. Flash flooding can occur in almost any area where there are steep slopes. This particular type of flooding commonly washes away houses, roads and bridges over small streams and may have a critical impact on communities and transport in these often remote areas.

Key features of flash floods as defined by the Environment Agency in England and Wales are:

- The short lead in time involved (usually defined as less than **six hours**).
- The short duration of the flooding.
- The link to heavy rainfall.
- Dam failure as a possible cause.
- The volume and velocity of water involved.
- The danger presented by debris.
- The potential to cause material damage.
- The urgent threat to life

Flash flood occurs in mountain streams and upper tributaries with relative small catchment areas. Small catchments have smaller storage and hence water moves out of the catchment faster (usually within six hours) and in greater volume per unit area than larger catchments. It should be noted that heavy rainfall accumulation is a necessary but not sufficient condition to induce flash floods. Hydrologic factors such as the initial soil moisture state and/or soil composition are critical for triggering a flash flood too. The intensity and impact of a flash flood event will be related to:

- Magnitude, efficiency, and direction of runoff
- Antecedent basin and stream flow conditions
- Size of the drainage basin

- Precipitation intensity
- Precipitation duration
- Storm location, movement, and evolution with respect to the basin
- Soil type, soil depth, and antecedent soil moisture conditions
- Amount and type of vegetation covering the soil
- Land use characteristics including urbanisation and deforestation
- General topography and slope of the land
- Time of year (season)

Although flash floods can be caused or enhanced by many different factors, rainfall-induced events do have a few things in common:

- Convective storms, from which large quantities of precipitation can fall rapidly
- Anomalous amounts of moisture, often through a deep layer of the atmosphere
- Moist low-level flow that rapidly replenishes moisture that supplies the storm
- Atmospheric flow conditions that encourage storm cells to mature or move in sequence over the same general region

Fluvial Floods

Fluvial flooding occurs over a wide range of river and catchment systems. Floods in river valleys occur mostly on flood plains or wash lands as a result of flow exceeding the capacity of the stream channels and spilling over the natural banks or artificial embankments.

Usually occurs along major rivers and in lower tributaries of large catchments. Since a river usually takes time to build up to its flood stage, sufficient time is usually available for people to make necessary arrangements and preparations and therefore river floods are a threat especially to properties. On the other hand flash floods are often more damaging, characterised, as the name implies, by the rapidity of formation following rainfall and high flow velocities. The rapidity makes them particularly dangerous to human life.

Flood Forecasting

Flood forecasting is the use of precipitation (real-time or forecasted) and hydrology data (stream flow, soil moisture, snow melting…) in rainfall-runoff and flow routing models to forecast flow rates and water levels for certain areas. The precise role and domain of flood forecasting will vary according to the circumstances dictated by both the hydro-meteorological environment and the built environment; urban areas presenting different problems than rural areas. The nature of flooding events is also important, particularly whether floods are regular in occurrence, as in a highly predictable seasonal climate, such as monsoon or hurricane seasons, or irregular, such as violent thunderstorms. Finally, the type of event is very relevant to the flood forecasting strategy, especially considering the different lead time that riverine floods and flash floods have. This is very relevant to the project area considered in this study.

There is thus no set design for a flood forecasting system, and the balance between particular components, for example meteorological and hydrological forecasts, scale and timing, have to be adapted to circumstances. Within a given area or country a number of different flood types may be encountered and each will require a different forecasting approach. Headwater areas may require a system concentrating on flash floods, whereas flood plain areas may need a system to be focused on the slow build-up of flooding and inundation. This will be fully addressed in the following sections regarding the study area.

Definition of flood forecasting and warning system

To form an effective real-time flood forecasting system, the basic structures need to be linked in an organised manner. This basically requires:

1. Provision of specific forecasts relating to meteorological variables (especially rainfall), for which numerical weather-prediction models are necessary;
2. Establishment of a network of manual or automatic hydrometric stations, linked to a central control by some form of telemetry;
3. Flood forecasting model software (including both hydrology and hydraulic modelling), linked to the observing network and operating in real time.

One very important distinction to establish is the difference between flood warnings and forecasts, as warnings are issued when an event is occurring or is imminent.

Full Flood Forecasting Early Warning System

The basic idea behind early warning is that the earlier and more accurately we are able to predict potential risks associated with natural and human induced hazards, the more likely we will be able to manage and mitigate a disaster’s impacts.

A full flood early warning system is an integrated system of tools and plans that guide detection of and coordinates response to flood emergencies. A properly designed and implemented system can save lives and reduce property damage by increasing the time to prepare and respond to the threat of flood and time available to take protective measures prior to the occurrence of flood.

A full flood forecasting early warning system makes use of the flood forecasting system (as described above) to address those main four components.

Community based Flood Early Warning System

A community based flood forecasting early warning system (CBFFEWS) is a locally based operational flood forecasting and warning activities of a community that aids them in mitigating the effects of flooding in their area. This is usually a relatively cheap, easy to sustain system enhanced by the direct and active participation of the community and its leaders. The ultimate goal of the system is to protect life and property by achieving and maintaining a high-level of community preparedness through timely flood information and warnings. This system is more important and efficient in areas prone to floods.

The most important characteristic of a CBFFEWS is community participation and empowerment. It empowers the people of the community to protect, prepare themselves and make them resilient against the disastrous effects of floods. The community is in the best position to undertake preparedness measures against floods.

The presence of a full flood forecasting (operational) framework for an early warning system alone sometimes is not enough to effectively minimise or prevent the damages from flooding. Early warning systems are sometimes neglected by the people, especially if they are not involved or fully aware of all the implications. One of the main challenges in early warning systems is implementing and sustaining it. The idea of incorporating the active involvement of the people in the community with an early warning system aims to increase the effectiveness of such systems. Learning by actual participation and taking part in the system enables people to understand more the value of these systems not only for themselves but for the whole community that will be affected, and make them become more responsible in performing their tasks in implementing and sustaining the system.

There are several factors to consider if a full and a community based EWS are compared:

Design: a full EWS design is usually based on legal mandate by government agencies while a community one is flexible and based on the actual needs.

Staff on charge: a full EWS should be managed and implemented by technicians and specialists. In a community one, however, the involvement of *ad-hoc* volunteers and local leaders is required.

Trigger: indicators, prediction and technology are used in a full EWS, whereas personal local detection of hazards are usually used in a community EWS.

Warning process: Usually in a cascading or fanned (in phases) in systematic manner for a full EWS. In a community EWS the warning process is usually Ad hoc, although it may be naturally well organised and cascading/fanned also.

Documented: while a community EWS is usually informal and rarely documented, a full EWS is documented through legislation, policies, standard operating procedures, MoUs, etc.

Monitoring: this is one of the most important differences between full and community FFEWS. In a full FFEWS automated gauge systems and satellite monitoring data flow into a system in real time, hosted in a centralised location and maintain by competent organisation, and current and forecasted conditions are based on implemented models. In a community FFEWS, manual river and rainfall gauges are usually used.

Warning communication: local communication devices, such as word-of-mouth, bells, drums, speakers, flags or telephone are basically used on community FFEWS. In full ones, radio, telephone, television, Email, internet or RSS feeds are mostly used. These differences between community and full EWS are based on common practices, but they do not necessarily define a system, and a community based EWS may have some of the characteristics of a full one (and the other way around). In some cases, a community EWS may be part of a broader scale full EWS. For example, a full EWS may provide the forecasting and monitoring data to a community EWS, in this case the community system being based primarily in the response.

4.1 Flood EWS Approach

The flood EWS will be based on a combination of both a full and a community-based EWS. This is because the nature of the floods existing in the selected communities.

The main objective from a national level point of view would be to support communities. In order to do that, there are several activities planned at this level:

- Maintenance and exploitation of the weather stations database
- Upgrade of existing weather stations to automatic capabilities
- Provision of initial forecasting information to communities and the general public
- Support communities in the deployment, maintenance and operation of the required sensors

From a community-based point of view the following activities are recommended:

- Deployment of required sensors, automatic weather stations, water level sensors
- Deployment of communication devices (sirens)
- Implementation of evacuations routes and centre

4.2 Site Selection

Two different locations have initially been selected for the flood EWS, namely Cassa (Ainaro) and Aissirimou (Aileu). This selection has been undertaken after a field visit, after discussions with local representatives and after discussions with NDOC staff. It should be noted that these locations can be altered, and that in this section the Aissirimou site will be presented.

4.3 Initial Assessment

The main aim of this assessment is to set up the initial stages required in order to fully develop the guidelines for the implementation of a Flood Early Warning System. This is required especially for the flood hazard, although different assessments at different levels for all the hazards will be required.

There are different tasks within this assessment:

1) Understand flooding characteristic of the basins, and the risks to existing communities.
2) Define sub-catchments that includes communities at risk
3) Undertake high-level initial assessment of likely response characteristics of the catchments. This initial assessment will include:
    a. Communities are risk and their likely lead times
    b. Define communities depending on lead time
    c. Initial definition of a full national flood EWS

Task 0.1 Understanding flooding characteristic and risks to existing communities

The consultant has undertaken a field trip to the study area, visiting communities where flooding has been previously reported and also visiting watercourses upstream of those communities. Also, in order to fully understand the flooding mechanism, the consultant has gathered as much information as possible and has spoken to several organisations and individuals.

Catchments in the study area have some geometry common features (Figure 1) such as very high slopes, a more defined channel network in the upper catchment and with a dendritic shape; a narrow middle section where slope is diminishing slightly; and a wide lower section were channels are not so well defined, very low slopes and with numerous interconnecting channels with active morphodynamics, behaving like an alluvial fan. Water velocities during flood events, however, appear to be significantly high due to the very high slopes in the upper side of the catchments, showing a very flash-flood behaviour. Due to the size of the catchment, fluvial flooding does not initially appear to be relevant. This, nevertheless should be addressed through a more detailed analysis. These high velocities and slopes leads to very active sediment transport events. A significant amount of sediment of various sizes is transported during flood events and deposited along the watercourse. Of course, deposition is more relevant where water velocities are smaller (smaller slopes), in the lower section of the catchments.

Figure 1 – Study area

Due to the intensity of events river channels are significantly wide in most river sections even if the base flow during most of the year is just occupying a minimal fraction of that river channel. During flood events the whole channel is occupied by the flow.

The flooding mechanism in the study area can therefore be explained by:

- Capacity issues: flooding in the study area can be usually explained through capacity issues. Although natural process seem to have been exacerbated due to climate change effects, flooding is a natural process occurring periodically in most river systems. In this case, very high rates of precipitation and the subsequent high run-off rates (associated to high slopes and low infiltration) discharging into the different watercourses exceeds the channel capacity and therefore flooding occurs.
- Flood protection: how this flooding has been addressed is also very significant in understanding flooding mechanisms. Hard engineering, namely flood walls, has been used in some locations in the study area to protect communities from flooding, although this protection is minor. It should be noted that this system is successful if all the areas in danger are covered, if walls are continuous and if walls are well maintained. During the field visits, the consultant had the opportunity to examine some of the wall-protected areas (), finding in this case that wall ended abruptly and probably just protecting fluvial structures. During flood scenarios water can escape the river channel through those gaps (or creating new ones in weak areas), inundating vast areas.

Figure 2 – Study area

- Morphodynamics: the very active morphodynamics previously noted are very significant from a flooding mechanism point of view, especially regarding deposition patterns. In the lower section of the catchments, deposition is very intense, and because velocities are not usually high in those areas and the deposited material is very coarse to be re-suspended at this stage, the bed level has risen lately. This could lead to issues, especially if the river bed keeps rising, and even to levels above the surrounding floodplain.

Task 0.2 Define sub-catchments that includes communities at risk

One of the key tasks prior to the development of the implementation guidelines and approach for a flood EWS (either a full or a community based one) is to identify communities at risk.

As previously noted, Cassa and Aissirimou communities have been initially selected, based on the field site visits, information from risk assessments and consultations with national and local NDOC staff.

The definition of sub-catchments exercise has been just undertaken for the Aissirimou community. This can be easily replicated in other communities, including Cassa village. Thus, a sub-catchment was derived for the Aissirimou village (Figure 3).

Figure 3 – Catchment for Aissirimou (red polygon)

Task 0.3 High-level initial assessment

During this initial assessment, the idea it to define

a. Communities at risk and their likely lead times
b. Communities depending on lead time
c. Initially a full national FFEWS

a. Communities at risk and their likely lead times

Information from the previous task has been analysed and processed in order to derive sub-catchments and time of concentration. The time of concentration can be defined as the time that water takes from the top of the catchment to the selected location in question. Time of concentration is therefore directly related to the lead time (warning time before the event occurs). It should be noted that the time to concentration for the selected communities was derived using ArcHydro tools and that the accuracy of this derivation may be improved once a full hydrology and hydraulic model has been fully implemented in the area. As a rule of thumb, it has been considered that if a community has a time to concentration lower than 6 hours, it can be considered as a flash-flood communities and that if a community has a time to concentration higher than 6 hours, it is a fluvial flooding community.

Aissirimou has a time to concentration of around 2 hours, and therefore flash-flood processes are expected here. As previously noted, the accuracy of this exercise can be further refined with more detailed modelling implementations. The results, from this exercise, though, are not expected to change much based on the field visit observations and the analysis of the collected information.

A thorough analysis of the basin characteristics, flood history, environmental factors and economic factors within the community sub-catchments detailed above should also be undertaken prior to the implementation of any EWS.

b. Communities depending on lead time

It appears that Aissirimou village can be classified as a flash-flood community due to the associated lead time. A more detailed analysis can be undertaken if more communities are identified or if a comprehensive modelling system is developed for these catchments.

c. Initially a full national FFEWS

As previously described, there are some differences between a full and a community FFEWS. The scope of the project does emphasise community early warning system. The involvement of the community is highly desirable in order to ensure the proper implementation and maintenance of a flood forecasting system. Without the involvement of local authorities and communities at risk, government and institutional interventions and responses to hazard events are likely to be inadequate.

A local, 'bottom-up' approach to early warning, with the active participation of local communities, enables a multi-dimensional response to problems and needs. In this way, local communities, civic groups and traditional structures can contribute to the reduction of vulnerability and to the strengthening of local capacities.

The involvement of the community can take place in any of the four components of the early warning system (risk analysis, monitoring and forecasting, dissemination and response). In most cases the community is involved in the monitoring and dissemination component because it is the probably the most direct link with the event. "User friendly" monitoring instruments are usually installed and managed by communities, and dissemination devices appropriate for every community are deployed. In this case, however, monitoring and first-hand dissemination does not seem to be the best way to involve the community. The short lead time estimated and the flooding mechanism in the area indicate that the main monitoring requirement in order to provide sufficient lead time should be rain-gauges deployed in the upper mountains, upstream of existing communities, and water level gauges upstream. Therefore, it is recommended, that at this initial stage, the community involvement in the flood early warning system should focus in both the risk assessment and, especially, in the response components. This community-based early warning system should be embedded into a full early warning system, where monitoring and forecasting and initial dissemination activities are carried out by a centralised and more technical organisation.

The initial design of such full flood EWS is depicted below. The full flood EWS should cover the four components of the classic EWS, while the community one should contribute in the risk and the response one. The community should also participate in the dissemination within the community (Figure 4).

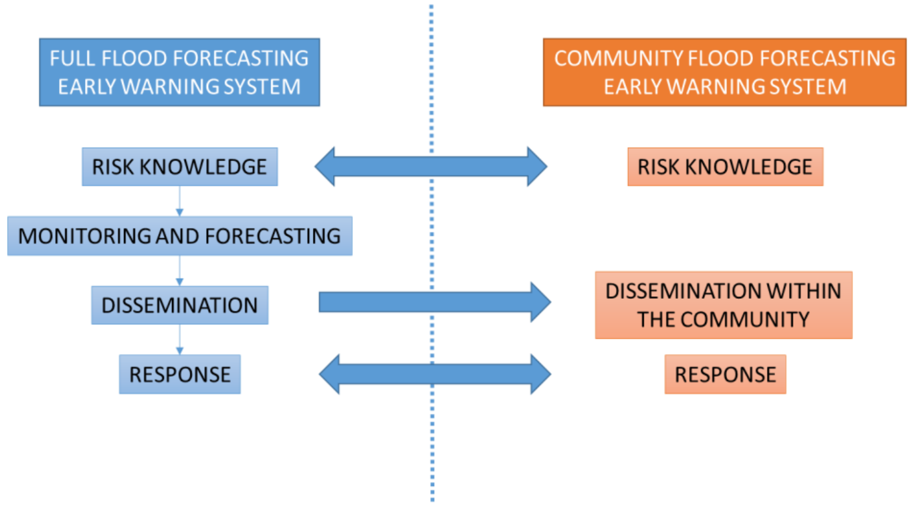

Figure 4 – Proposed full and community EWS

4.4 National Flood EWS Support

4.4.1 Risk Assessment

A national flood risk assessment has been carried out for the whole Timor Leste territory (by UNDP) and also within the study area (by the Work Bank). Information about this risk assessments can be found in the second deliverable of this consultancy ("Fact finding report on existing EWS in Timor-Leste based on stakeholder consultations and a stakeholder workshop"). These risk assessments are based on certain catchments in Timor Leste and also in the study area within the road corridor. The World Bank flood risk assessment addressed two different catchments, the Be Lulic and the Laclo (in the Aileu district) catchments. This risk assessment covers in detail the two pre-selected locations for the flood EWS and it is considered suitable at this stage. However, there are some tasks at national level regarding risk assessments:

- The two flood risk assessments above-mentioned were undertaken using hydrological and hydraulic modelling. It is recommended that a national organisation, preferably the National Directorate for Water Quality and Control (NDWQC), takes ownership over these two different models, if available.
- Further sensitivity tests should be carried out with these two models, especially due to the uncertainty regarding data availability.
- Further assessments should be carried out with these two models in order to properly assess time to concentration and flood areas.
- As described below, maintenance procedures should be implemented, and flood hazard and risk maps should be re-visited periodically.

Furthermore, risk dissemination activities should be carried out. Information from the flood maps should be made available to both the general public and the regional and local administrators.

4.4.2 Monitoring and Warning

Monitoring and warning services lie at the core of the system. There must be a sound scientific basis for predicting and forecasting hazards and a reliable forecasting and warning system that operates 24 hours a day. Continuous monitoring of hazard parameters and precursors is essential to generate accurate warnings in a timely fashion. Warning services for different hazards (flood in this case) should be coordinated where possible to gain the benefit of shared institutional, procedural and communication networks

There are several activities at National Level that should be undertaken. The main purposes of these activities is to support local communities in the operation of the EWS.

- The main activity at national level would be the maintenance and exploitation of a database. There are more than 80 weather stations in Timor-Leste.
- The number of these stations that can be converted in automatic weather stations with telemetry capabilities is still unknown. However, it is recommended that resources are allocated for this purpose in order to improve both forecasting and climatological capabilities.
- Information from the monitoring system deployed in the communities will be received both by the communities but also at national level. The National Directorate for Meteorology and Geophysics (NDMG) and the National Directorate for Water Quality and Control (NDWQC) should collect the information from the automatic weather stations and the water level monitors respectively.
- Also, it is recommended that forecasting (precipitation) information is used. At this stage, a threshold approach is recommended. In order to do that, a climatological study has to be undertaken in order to find the different thresholds, using previous flood events and associated precipitation and conditions.

The whole monitoring and warning system depicted is shown in Figure 5

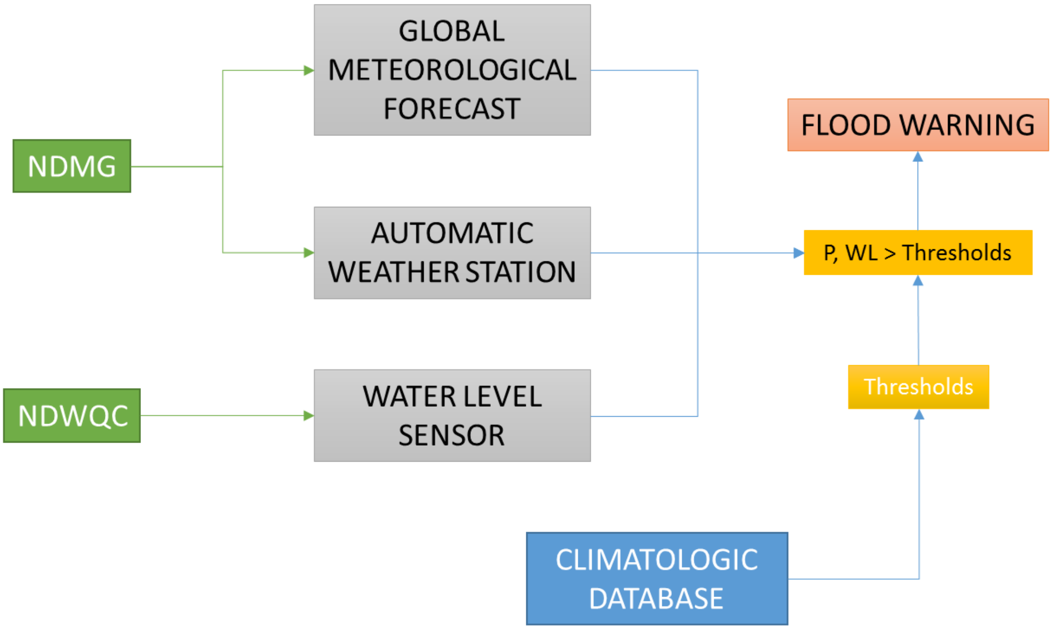

Figure 5 – Monitoring and Warning System

It should be noted that the capacities of the existing network should be considered for both precipitation and water level monitoring purposes. The location of all the existing meteorological stations was detailed in the Deliverable 2 of this consultancy. No information was available at that stage regarding hydrological stations. Figure 6 shows the existing weather and water level stations in Timor Leste. The status of the water level stations is unknown, but it does appear that they are manual stations and therefore they are not useful for early warning / forecasting purposes. Nonetheless, data from these stations should be analysed for climatological purposes.

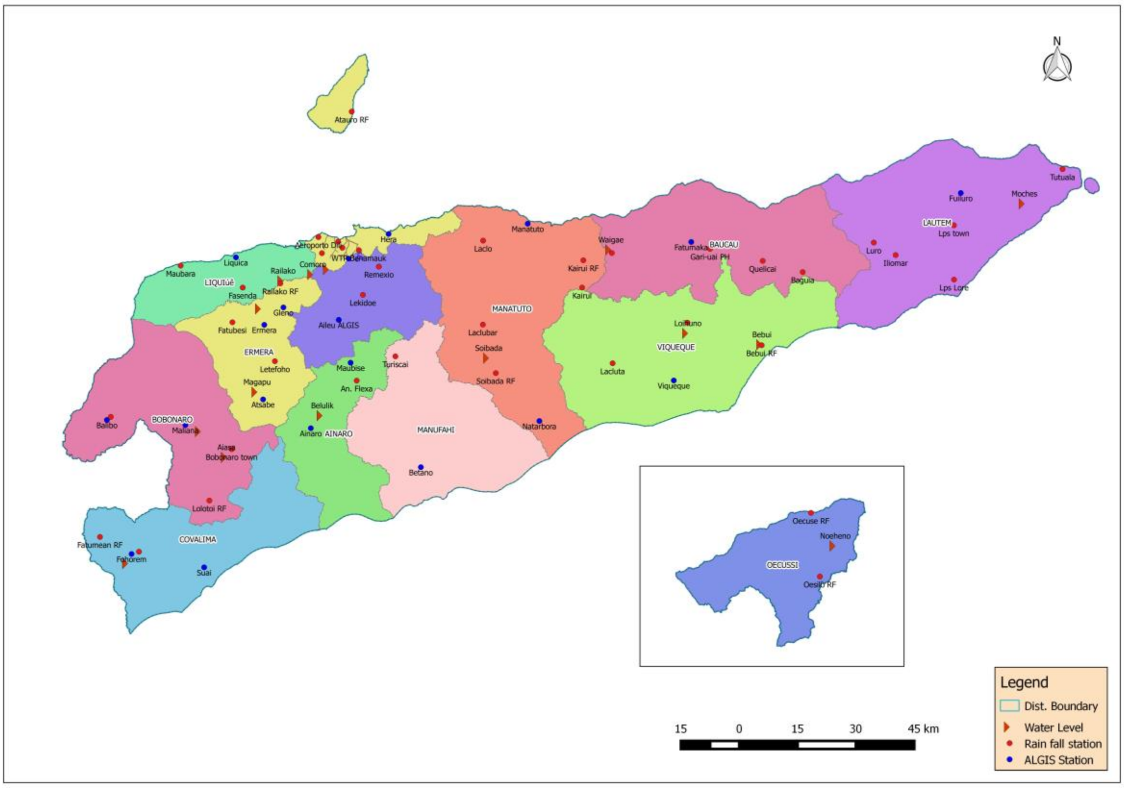

Figure 6 – Existing weather and water level stations in Timor Leste

4.4.2.1 Definition of Warning Levels

Warning levels should be defined for the flood and all the other hazards. These warning levels should be the same for all the different organisations involved in the EWS and the disaster risk management in Timor Leste. These different levels should be easily understood by all the different organisations. There are already different levels, as defined by NDOC or by the Red Cross, in Timor Leste. The recommended warning levels are:

- Green Status – No significant hazard expected. At this level, the forecasting and monitoring network does not predict any impending event.
- Yellow Status - Be Aware: The concept behind yellow level alerts is to notify those who are at risk because of their location and/or activity, and to allow them to take preventative action. Yellow means that the general public in those locations should plan ahead thinking about possible travel delays, or the disruption of day to day activities. The developing weather situation is being monitored and Yellow means that an eye should be kept on the latest forecast and be aware that the weather may change or worsen, leading to disruption.

- Orange Status - Be Prepared: This category of orange level weather warnings is for weather conditions which have the capacity to impact significantly on people in the affected areas. The issue of an Orange level warning implies that all recipients in the affected areas should prepare themselves in an appropriate way for the anticipated conditions.
- Red Status - Take Action: the issue of red level severe weather warnings should be a comparatively rare event and implies that recipients take action to protect themselves and/or their properties; this could be by moving their families out of the danger zone temporarily; by staying indoors; or by other specific actions aimed at mitigating the effects of the weather conditions. Extreme weather is expected.

Regarding the criteria for defining the different levels, this is also something that should be specified for all the different hazards and agreed by the different stakeholders. Regarding the flood hazard, two different approaches should be followed at this stage. In the first case, at national scale, forecast warning based on numerical weather prediction models, should be used. As previously noted thresholds for this should be defined through a climatological study. Some examples could be:

	Green	Yellow	Orange	Red
Precipitation Thresholds for Floods	Less than 30mm in 24h	30mm – 50mm in 24h	50mm – 70mm in 24h	70mm or greater in 24h
	Less than 25mm in 12h	25mm – 40mm in 12h	40mm – 50mm in 12h	50mm or greater in 12h
	Less than 20mm in 6h	20mm – 30mm in 6h	30mm – 40mm in 6h	40mm or greater in 6h

Table 1 – Example of different precipitation thresholds for warning purposes

In the second hand, at a community level, threshold levels should be defined using information from the monitors. This will be further described in the community-based EWS section.

4.4.3 Communication and Dissemination

Warnings must reach those at risk. Frequently, the lack of ability to disseminate warnings to the population at risk is the weakest link in an integrated system. Forecasts and warnings must reach users without delay and with sufficient lead-time to permit response actions to take place.

Clear messages containing simple, useful information are critical to enable proper responses that will help safeguard lives and livelihoods. Regional, national and community level communication systems must be pre-identified and appropriate authoritative voices established. The use of multiple communication channels is necessary to ensure as many people as possible are warned, to avoid failure of any one channel, and to reinforce the warning message.

The message to be communicated should also be clearly understood by all the different receivers. Also, the message should contain the information needed by all the different parties. Therefore, different messages should be defined depending on the receiver.

In this case, the communication with the communities is probably the most critical issue. The communication means should consider existing rural conditions in most of the communities in the Dili-Ainaro road corridor. Dissemination of forecasts and warnings can be achieved through a variety of communication methods. It should be noted that in this case two different sets of communication methods should be utilised. As previously described, the proposed design for the monitoring and warning component does not reside entirely within the community. Therefore, mechanisms for the communication between the 'operational centre' and the communities and also mechanisms for the communication within each community will be proposed. The latter will be described in the community section.

4.4.3.1 Communication with the Communities

This could be one of the weakest links within the whole scheme, and thus special care will be taken in designing this stage of the system. The operational centre has to be able to notify the communities of the incoming warning as soon as possible after the warning has been identified in order to ensure that the lead-time is as much as possible. This notification has to be undertaken through reliable means and redundancy has to be considered in order to avoid potential issues. At least two contact people per community will be identified, but means to warn communities remotely will also be proposed.

In order to reduce the possibility of issues, the communication with the communities will be carried out through the operational centre, through the district DOC office and through the local contacts. Also, the district DOC office will contact the local representative.

The following means of communication are considered.

1. Mobile phone-SMS

Mobile phones can be used as communication devices at the two different communication levels considered. In the case of communication between the operational centre and a local contact in the community, this can be really useful, but it has some drawbacks, because the mobile phone has to be always available and working, and the contact person has to keep his/her mobile phone always available. Also, SMS can be sent to all groups of people registered in the community-based scheme, facilitating the distribution of information to a large number of people. At this point two different initiatives should be noted. In the first place, the National Communication Authority of Timor Leste is being formalised at this stage and an Emergency Communication Plan is being drafted.

Also, the SATA Moris (SMS AlerTa Asegura Moris/SMS Alerts for Securing Life). This UNDP project aims to put in place a pilot real time data collection, data analysis and dissemination system to ensure timely data and response in the event of natural disasters happen in Timor Leste. The system will comprise of mobile phone handsets at community level and a central database at national government ministry level. The community level mobile phone sets will be used to transmit data from the community about the natural disaster occurrences, and provide feedback to communities about early warning and planned responses, while the central database system will be used to analyse data and generate information to be used for early warning and response planning.

It should be noted that the mobile network reliability can be compromised during some weather conditions, and therefore back-up systems should be considered. The consultant, during several meetings and field visits, enquired about the mobile network reliability under certain circumstances. The answers varies, but it is evident that the network is not always working and that sometimes the communication between Dili and communities in the road corridor is not always possible through this mean. Therefore, it is highly advised that alternative communications means are provided.

2. Radio HF

High Frequency radio is considered as a suitable communication mean with the communities, providing the necessary infrastructure is provided. Radio HF can work under harsh weather conditions, and therefore is an excellent redundancy system if the mobile network is not operating.

3. Email - Internet

In communities sufficiently developed whereby a large percentage of individuals have email and web access, communication via email is extremely effective; especially as smartphones also have 3G/ 3GS or 4G capability, meaning that users can check their email accounts and surf the web anywhere there is cell phone access. Websites are quickly and easily updated, and emails can be mass disseminated to huge numbers of users simultaneously via the appropriate email software program. However, despite the positive aspects of using the internet for knowledge dissemination, in rural areas in Timor Leste, email and website communications methods have very limited applicability. Although 3G access is fairly widespread and consistent, most rural residents do not possess smartphones. Computers are not common; in some communities, they are hard to locate even in the commune offices. There are doubts about digital equity in the study area, and therefore email and web-based forms of communication cannot be recommended as an effective early warning tool in this scheme. It cannot be relied upon for direct communications of warnings or evacuations.

4. Sirens (Remote Control for Siren Systems)

There are some siren systems that can either be local or remotely activated. The remote activation can be triggered through radio, GSM or telephone landline or internet network. This siren system is suitable for this type of scheme, and it does allow for several types of messages or alerts. The remote activation feature will be highly useful when the warning is produced at night and/or the local contact cannot be reached.

4.4.3.2 Communication at National Level

The communication at national level between different relevant organisations should also be properly defined. The main scope of this EWS is at community level, and therefore this communication at National Level is not considered deeply. Nonetheless, new Standard Operating Procedures (SOP) for the communication and response during disasters are being implemented in Timor Leste. The consultant, after revising the latest version of these SOP, finds this approach satisfactory and adequate. This information has been included in the Deliverable 2 of this consultancy and it will not be replicated here.

4.4.4 Response

The response of different organisations during disasters in Timor Leste has proven to be very problematic. Poor coordination between all the organisations involved in disaster response has previously led to significant issues. It is very important that roles and responsibilities for the response component are clearly defined by policy and regulations. As previously stated, new SOP are being drafted and this is being accomplished. Within this document, the response within the communities (detailed in section 4.5.4) and possibilities of monitoring during response will be detailed.

4.4.4.1 Monitoring During Response

One of the most significant issues during the response is the monitoring of existing conditions. There are several resources available in order to get information about the existing situation of a flood during the response. This is very significant information for the response organisations, such as civil protection, NDOC, firefighters or the police. In some cases, information from forecasting and (hydraulic) modelling sources can be used. However, in this respect, there are no hydraulic forecasting models implemented in Timor Leste, and therefore the use of monitoring sources for response planning should be used.

Information from local community members, information from NDOC focal point, information from aerial resources and especially information from earth observation resources should be considered. Flood outlines from satellite resources can be obtained from several sources.

The use of Synthetic Aperture Radar (SAR) images for flood monitoring has been widely proved to be useful recently. SAR measurements from space are independent of daytime and weather conditions and can provide valuable information to monitoring of flood events. The fundamental characteristic recorded on a radar image is the backscattering coefficient, which may vary from surface to surface. The strength of the returned signal from the surface is influenced by the combination of both system and ground parameters. These parameters are the average surface roughness and soil dielectric properties. Horizontal smooth surfaces, such as water bodies, reflect nearly all incident radiation away and the weak return signal is represented by dark tonality on radar images. This is mainly due to the fact that smooth water surface provides no return to antenna in microwave spectrum and appears black in SAR imagery.

The use of optical imagery for flood monitoring is limited by severe weather conditions, in particular presence of clouds and during dark conditions. The main satellite source to consider in this case would be MODIS. The high spatial resolution of MODIS and its twice daily near-global coverage are very interesting features and capabilities.

MODIS imaginary is currently being processed within NASA and yielding a near-real time global flood mapping product. This product is currently available on-line and is an open-source product (http://modis.gsfc.nasa.gov/data/dataprod/).

Information from the Darmouth Flood Observatory should also be considered, because they monitored floods worldwide (http://floodobservatory.colorado.edu/). The observatory has a mission to acquire, publish, and preserve for public access a digital map record of the Earth's changing surface water, including changes related to floods and droughts. Its products are based on various remote sensing sources, although especially MODIS sources are considered.

The processing of some of the satellite data in order to derive flood outlines and flood information requires certain technical expertise. Therefore, as it is noted below, it is recommended that an organisation in Timor Leste asks for membership for the International Charter of Space and Major Disasters, and in that way this information will be supplied directly to this organisation.

4.5 Community-based Flood EWS

As previously noted, the flood community-based EWS will be presented for the Aissirimou case (Figure 7). Aissirimou is located close to Aileu and in the bank of a watercourse. The consultant visited this community after being noted a location at flood risk by the NDOC focal point and the deputy district administrator in Aileu. As previously described, the whole process of the design and implementation will be depicted in order to allow for the replication of the implementation elsewhere.

Figure 7 – Aissirimou location and catchment

4.5.1 Risk Assessment

The risk knowledge component within the community-based EWS should be carried out with a significant input from the different affected communities. Risks arise from the combination of hazards and vulnerabilities at a particular location. Assessments of risk require systematic collection and analysis of data and should consider the impact of processes such as urbanisation, rural land-use change, environmental degradation and climate change. Risk assessments and maps help to motivate people, prioritise early warning system needs and guide preparations for disaster prevention and responses.

A review of the existing risk knowledge regarding flooding in Aissirimou was carried out by the consultant. A specific task (Task 2) has been devised for the implementation of this component. It is recommended that flood maps for the study area, as developed by both UNDP and the World Bank, are printed in detailed for the community and distributed. It would be recommended that maps are presented for several return period scenarios but also for previous events. This will allow the validation of the maps thanks to the information contributed from the community regarding the extent of the flooding for certain known events. The consultant has digitised the information from the World Bank risk assessment exercise in Aissirimou in order to shown initial areas at risk (Figure 8).

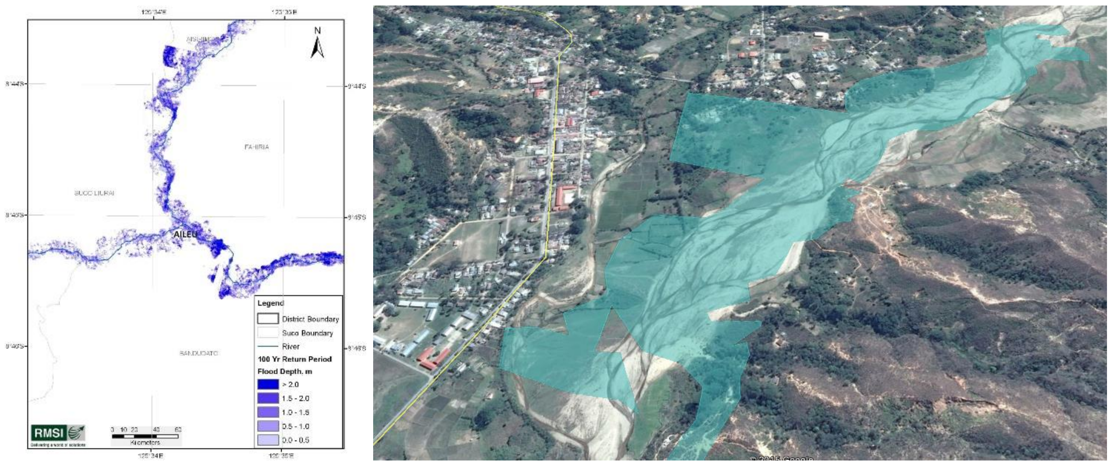

Figure 8 – Aissirimou floodplain

Once risk maps are validated for this area, they should be disseminated throughout the whole community.

4.5.2 Monitoring and Warning

The monitoring and warning component from a community perspective will be based on several different actions in order to ensure that no events are missed and that lead time is as high as possible. The system will work with the combination of all the different components but also considering the accuracy of every part of the system. The NWP (forecasting) system was also described in the national section. Because the sensors will be deployed at community level, they will be detailed here (Figure 9). Two automatic weather stations, one water level sensor and staff gauges are proposed in order to monitor and warn about floods in the study area. The management of the information from the automatic sensors and the forecasting system should be undertaken at a National level due to the complexity of this operation.

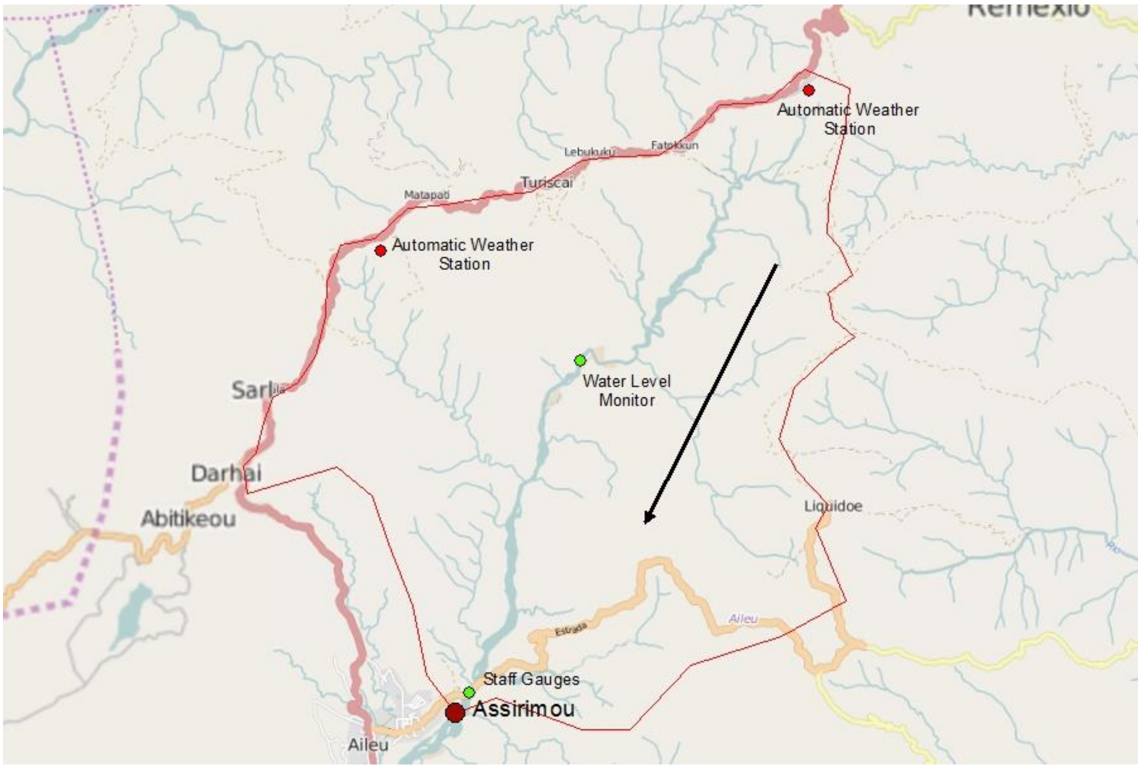

Figure 9 – Suggested location of monitoring devices in Aissirimou.

4.5.2.1 Forecasting

A forecasting system will be used in order to predict any disaster event in advance. This flood forecasting system will be based on a global weather system yielding meteorological forecasting information in the area of interest and it can be managed at a National level as previously described. The forecast time-span for this system can be as high as 240 hours (10 days). The accuracy of predictions, especially precipitation, decrease as the forecast time increases, and therefore, the higher accuracy is obtained for the first hours of the predictions. Based on international practice, any results further than 72 hours are not usually considered for any realistic prediction. Thus, the proposed system will start to work 72 hours in advance, although the predictions of flood events will be considered just 48 hours in advance.

4.5.2.2 Automatic Weather Station

The deployment of two different automatic weather stations with telemetry capabilities is recommended in this case. This is because two main different watercourse systems have been identified upstream of Aissirimou. The idea is that either (or both) of these stations will record precipitation in these two areas and will send warning messages once a (previously established) threshold is surpassed. Data will be send automatically to NDMG with a previously specified time step, usually every 3 hours.

4.5.2.3 Radar Sensor Type Water Level Monitoring

It is recommended that non-contact water level monitoring sensors (Figure 10) are deployed in the watercourse upstream of Aissirimou. The idea behind this deployment is to corroborate an incoming event as predicted by the precipitation sensors. These sensors will also provide very useful information regarding run-off times.

Figure 10 – Water level monitoring using radars.

The water level radar sensor is a measuring device for measuring the surface water level without direct contact to the medium. This is considered necessary due to the high transport capacity of these watercourses during flood events. Information from this station will be sent automatically and periodically to the NDWQC.

4.5.2.4 Community Water Level Gauges

Even if water gauging in the community does not directly yield any benefit to the EWS, it is recommended to monitor maximum water level in watercourses in the vicinity of the communities after significant flood events. This monitoring will fulfil three different objectives:

- Enhance the community involvement in the EWS
- Enhance the community awareness of the whole scheme
- Gather maximum level information for system improvement

Two different type of gauges are proposed:

- Maximum level gauges: these gauges (Figure 11 (a)) show the highest surface water level by colour marking. They are maximum level indicators for preservation of evidence and offer exact data for a later treatment of a flood event. In a measuring cylinder made of safety glass there is a 1 m long glass-fibre reinforced plastic measuring rod. A transparent self-adhesive colour band is fixed on the measuring rod. The rising water in the measuring cylinder rinses the colour out reliably, up to the respective water level. A sharp dividing line displays the highest water level. The exchange of the colour band is easily done via loosening the upper cylindrical head screw. The straining device acts as filter for coarse dirt and acts as a damping device preventing influence by wash of waves in the measuring cylinder.
- Staff gauges (painted): these gauges (Figure 11 (b)) can be easily painted in strategic locations in the communities (bridges, wall or any other structures). Maximum water level information can be estimated based on the change in colour in the staff gauge. These gauges are not as accurate as the maximum water level gauges depicted above, but they are cheaper and easy to deploy.

It is advised that every community report the maximum water level recorded after every flood event to the operation centre.

Figure 11 – (a) Maximum water level gauge and (b) staff gauge.

It should be noted that existing resources should be considered too, especially regarding existing weather stations in the study area. Figure 12 shows the stations located in the Laclo river catchment. There are two weather stations in the study area that can be relevant to the community monitoring network in Aissirimou, located in Aileu and in Lekidoe. The status of these stations is unknown, but if possible their telemetry capabilities should be upgraded and the information from these two stations should be used to complement the proposed system.

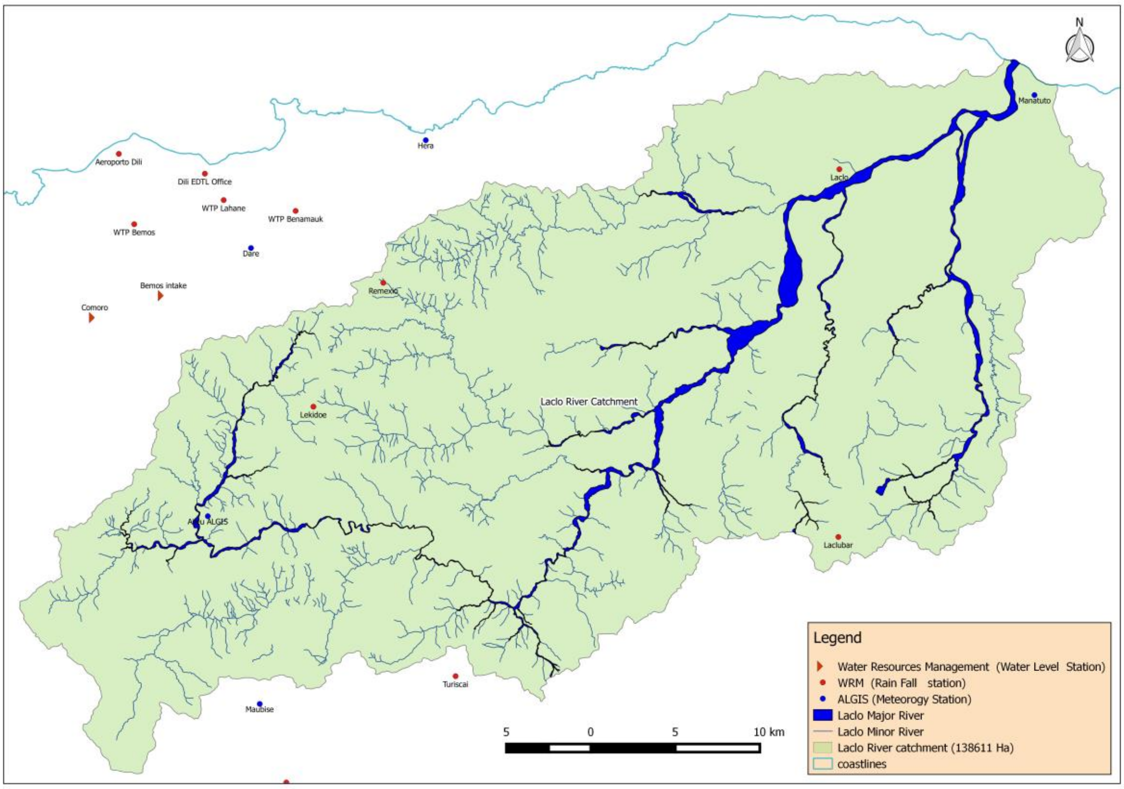

Figure 12 – Laclo River Catchment Monitoring Network

4.5.2.5 Definition of Warning Levels

The definition of the different thresholds for issuing warning levels will be based on local experience and in the information from previous events. Whenever these thresholds are surpassed, by the forecasting or the monitoring-sensor system, different warning levels will be issued (Figure 13).

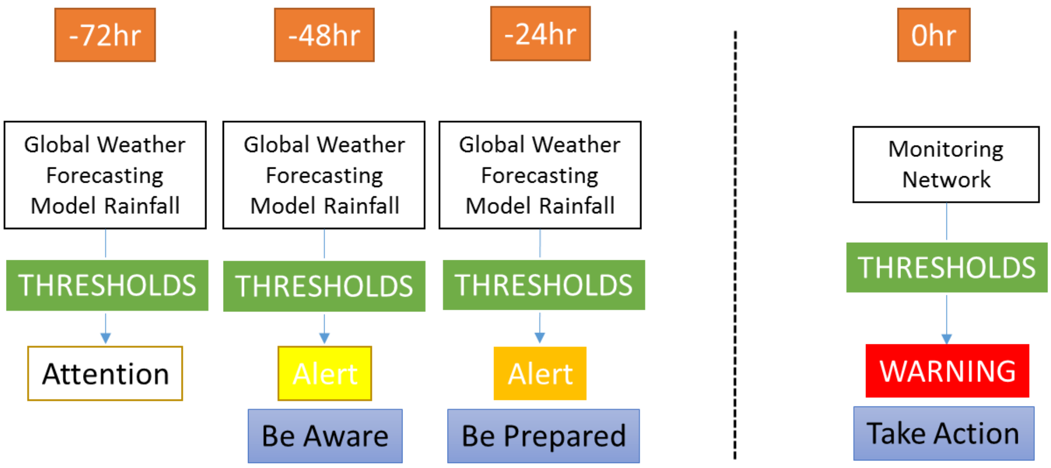

Figure 13 – Warning levels

4.5.3 Communication and Dissemination

Special care must be taken when designing effective communications systems within the communities in the Dili-Ainaro road corridor. There are different options to consider. The final decision on what communication means to use will be based on the community preferences and existing practices, reliability and the international expert advice.

1. Bells

Bells and/or drums are an effective, low-tech means of sounding an alarm to the community. Bells are inexpensive and easy to install; as they do not rely on electricity or batteries for operation; they are resistant to damage due to flooding; and there is no upkeep or maintenance cost. During the EWS implementation phase, the community would be asked to come up with a set of signals - a rhythm to communicate a particular response or action. When creating the signals, it is important that they be clear, easy to replicate, and also that each signal be significantly different from the next so that the listener does not get the messages mixed up. The creation of effective signals and the dissemination of their meaning to all community members are of the utmost importance; the creation and dissemination best occurs through community-wide workshops and training session.

2. Wireless Alert Sirens' System

In addition to the sirens noted above (remote sirens), there are wireless siren systems to be considered. This system can be really useful to alert people in small communities. Because it does not require any interconnecting (backbone) cabling or a central control panel, it is quicker and far less costly to install than traditional hard-wired emergency warning siren or PA (public address) systems.

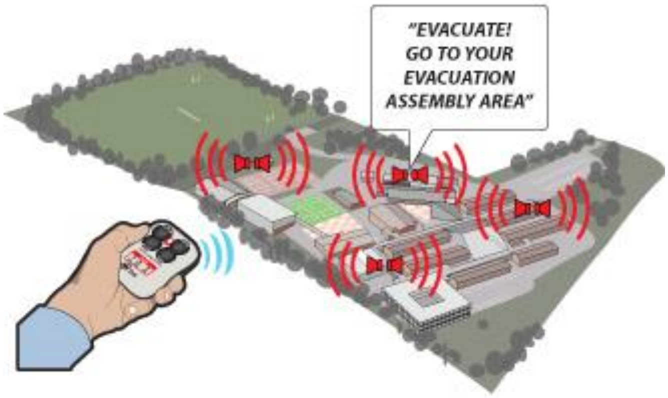

Figure 14 – Wireless sirens

This could be easily activated by the local scheme representative, and again, several types of messages can be pre-coded. However, it is recommended that if the remote siren system is deployed, sirens within this system should be able to be activated by both the operational centre and by the community itself.

3. Loudspeaker

Loudspeakers are very effective at transmitting relevant information to a local audience via announcements. There are two main types of loudspeakers; the handheld, portable battery-operated loudspeaker, and the hardwired system, whereby loudspeakers are posted in various areas throughout the community. The wired system has a larger reach due to the multiple speaker set up, and therefore has the ability to transmit information to entire communities at once, thereby saving time, which, in some emergency situations, is crucial. The drawback to the wired system is its propensity for breakdown due to technical issues, as well as its ability to be damaged in the event of a disaster. The handheld system is very effective in a crisis situation, as it is transportable and can be hand carried by the announcer during an evacuation. As it is battery-operated, it can be used during blackouts, which, in the event of a severe storm, can be prolonged, lasting for several days. However, some drawbacks of the handheld loudspeaker include its limited broadcasting range.

4. SMS

SMS has proven to be one of the most reliable and inexpensive means of mass communication in several EWS implementations. Transmission of information from one village to the next, from the village to the commune office, or the village to the NDOC, or vice versa, can be done via SMS. Mobile phones are widely available in Timor Leste, even in rural areas; most adults have a simple cell phone or have a family member with one.

Despite their usefulness, there are some drawbacks. Phones must also be kept charged, and in the event of a prolonged power outage, communication ability might be disrupted if the mobile phone’s battery runs out and no backup power generator can be found. Lastly, even though mobile communication towers usually have backup generators, in the event of a serious disaster, these systems might also fail, resulting in a prolonged telecommunications outage.

5. Walkie talkie

Walkie Talkies are excellent EWS devices, and have proven especially effective in evacuation situations in implemented EWS. They can be used to create a communication chain in order to relay information from one community to the next if necessary. This is necessary in communities that occupy a large geographic territory, as some villages are too far away from the commune office to communicate directly with the authorities via walkie talkie.

Another benefit is that walkie talkies are not dependent on the grid for power, as they are battery-operated or rechargeable; this makes them suitable for use during serious disasters where the infrastructure might be wiped out (obviously, they must be maintained – either recharged on a regular basis, or a stockpile of fresh, high quality batteries must be kept on hand for use during emergency situations).

6. Boards

Informative boards should be deployed in the community. These boards should contain information about the flood risk but also information about any forecasted event. Any information received by community leaders/representatives about any possible forecasted precipitation surpassing the defined thresholds should be noted in these boards.

4.5.3.1 Recommended System – Communication Flow

The warning dissemination system has to secure an efficient communication of warnings and other relevant information, including remote households with limited access to information and consider warning at any time during the day/week. The structural set up has to be clear to all stakeholders. They have to know who is supposed to inform them and they have to know whom they have to inform in turn.

Because of the high importance of this component and the fact that the monitoring component does not reside in the community, several redundant system are proposed. It is recommended that at least two local residents in every community are appointed as contact. The recommended system will be discretised depending on the warning level.

1. Level 1 Alert (***Be aware***) – 48 hours in advance

If the forecasting (NWP) system predicts that a local event may occur, local appointed residents will be contacted through mobile phone. Television and local radio will also be used to inform community members. Information will be displayed in local boards and in a dedicated webpage.

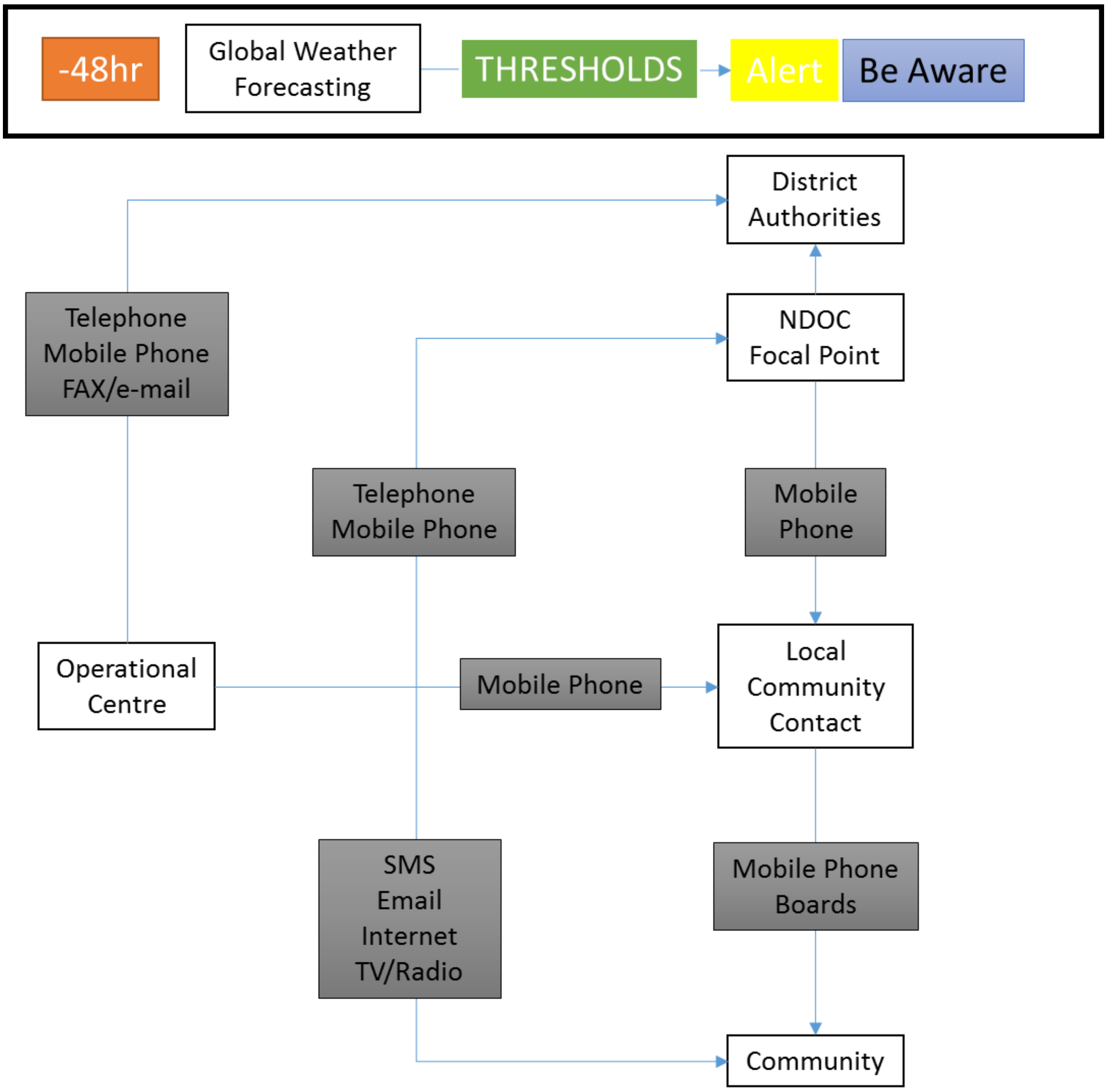

Figure 15 - Tentative communication for alert (be aware) situations

2. Level 2 Alert (***Be prepared***) – 24 hours in advance

If the forecasting system predicts 24 hours in advance that a local event may occur, local representatives will be contacted again via mobile phones. Television and local radio will also be used to inform community members. Information will again be displayed in local boards and in a dedicated webpage. SMS will be sent to registered members of the community.

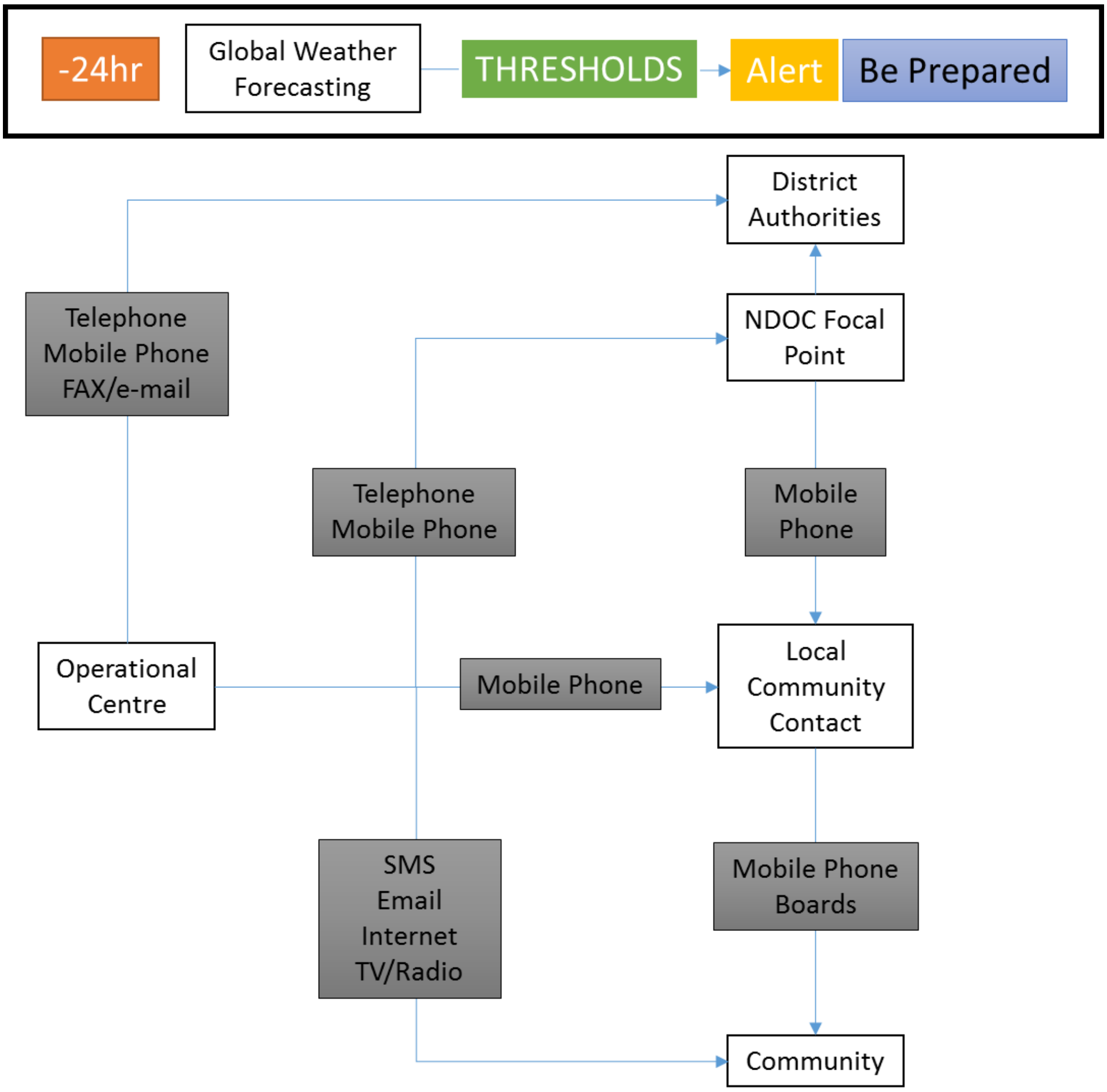

Figure 16 - Tentative communication for alert (be prepared) situations

It should be noted that, even if no event was forecasted 48 hours in advance, it can be predicted 24 hours in advance due to the higher accuracy of forecast during the first hours.

3. Level 3 Warning (***Take action***) - Event

This level of warning will be based on recorded rainfall and water levels further upstream, and therefore the certainty of the event is much higher. Local representatives will be contacted by mobile phone. Sirens will be operated remotely from the operation centre. Local representatives will be in charge of further alerting other members of the community through bells, walkie-talkies and/or (WIFI) sirens. Local Authorities will also be contacted by the main operational centre and all the rescue/disaster management organisations will be mobilised.

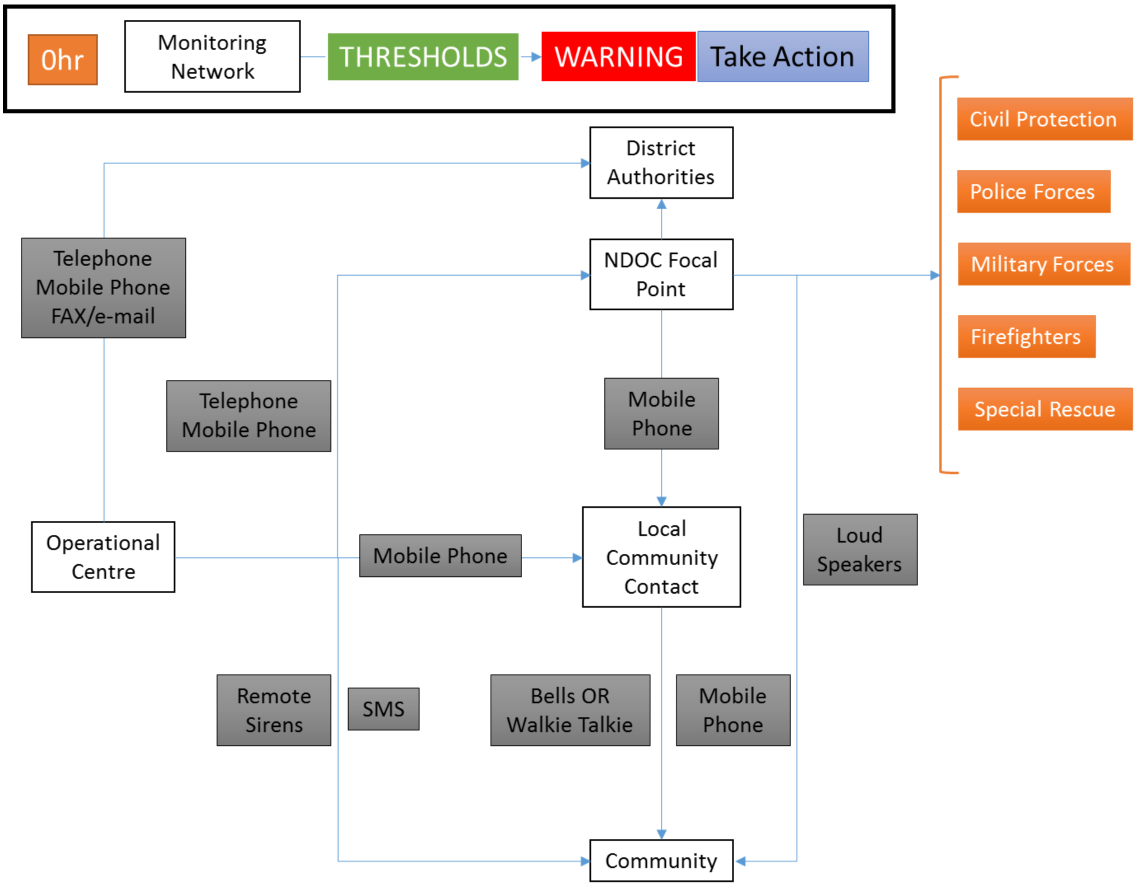

Figure 17 - Tentative communication for warning situations

It should be noted that a flood event, as registered by the monitoring system, may occur even if no alert has been previously been issued by the forecasting system, and therefore communities should be aware that the highest level of warning can be activated directly.

In emergency situations there is no time for lengthy conversations. The message has to be short and easily understood. This means the sender and the receiver of the message use agreed standard messages. The main agreed standards are the three warning levels (be alert, be prepared and take action). This requires that the sender of the message and the receiver need to have the same understanding of what the three warning levels mean.

The warning levels have certain preconditions and distinct expected actions. In order to avoid confusion, the content of the messages should to be clear to all concerned. Therefore, posters describing the three warning levels and the associated actions should be posted in communal areas.

Finally, it is recommended that the system is tested periodically (probably as part of a more complete drill programme) and that maintenance activities are organised.

4.5.4 Response

Even though the technical side of the EWS is complex, the greatest potential for failure exists if the local population is inadequately prepared for emergencies. Therefore, preparedness programs are an integral part of the project to support the population in EWS handling and emergency actions.

It is essential that communities understand their risks; respect the warning service and know how to react. Education and preparedness programmes play a key role. It is also essential that disaster management plans are in place, well-practiced and tested. The community should be well informed on options for safe behaviour, available escape routes, and how best to avoid damage and loss to property.

Some recommendations from a community point of view will be outlined below. The physical capacity to respond adequately should be established and how to react to certain emergency situations should be planned and people should be advised or trained to handle the emergency situation.

4.5.4.1 Establishment of Community Response Plans

All communities implementing the scheme should develop Community Response Plans (or Disaster Preparedness Plans). These plans are aimed at characterizing hazards and vulnerabilities as well as capacities and develop strategies and concrete steps on how to reduce the risks from hazards. This includes emergency response but it is not limited to it.

4.5.4.2 Evacuation Routes / Evacuation Centres

Evacuation routes should be investigated and described. These routes can usually be derived from the flood risk exercise, but local knowledge should also be considered. Also, not all the different flood events are the same, and therefore this should be considered when defining evacuation routes. A main evacuation centre should also be defined. Some community members may want to look for refuge in the houses of relatives or friends. This is not recommended unless there is certainty that this household will not be affected by the incoming flood event. Therefore it is recommend that a communal/evacuation centre is defined. Usually this centre can be an existing and suitable community property, although this suitability has to be properly assessed. The main evacuation routes and directions to the evacuation centre should be clearly signposted.

4.5.4.3 Enhance Public Awareness and Education

One of the reasons for absence or lack of adequate reaction to the danger of approaching floods is the lack of awareness among the general public of the underlying risk and the knowledge that something can be done to reduce it or to avoid the risk. Several awareness campaigns should be planned at community level in order to raise community awareness and to inform community members how to react when a warning has been communicated about an impending flood.

Special attention should be paid to children's' awareness. While adults have a big role in effecting behavioural change, in the long term perspective starting in school is the most promising strategy to facilitate this process. Children of school age are one of the most vulnerable parts of the population when disasters occur. Cognizant that the majority of these children are in school away from their parents and directly under the care of teachers during many hours per day, it is advisable to integrate schools in efforts to raise the awareness of children.

4.6 Summary

The initial design for the flood EWS is described in Figure 18.

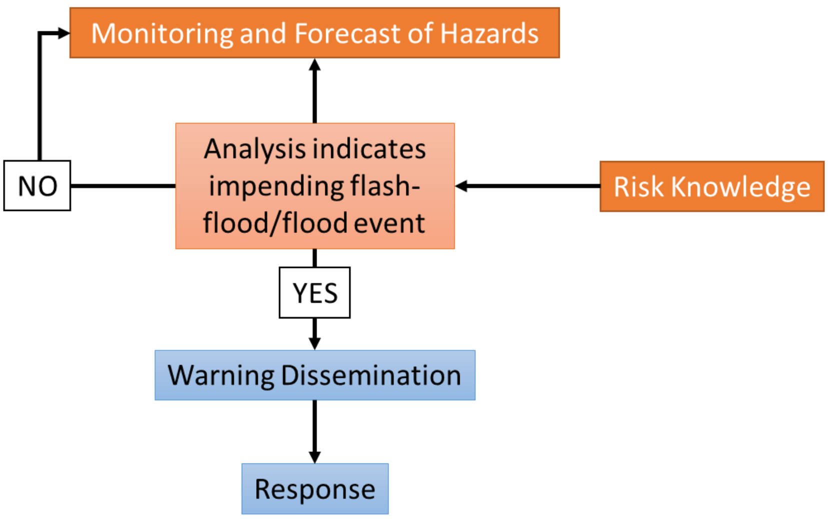

Figure 18 – Initial Flood EWS design

The flood EWS system has been described for the Aissirimou community. Due to the flash-flood nature of the watercourse in this location, several monitor mechanisms have been depicted. The management of the forecasting and automatic sensor system will be the responsibility of national organisations. The automatic sensors defined are automatic weather stations and water level monitors.

Depending on the nature of the warning, the communication with the communities will use different communication means. The higher the certainty, the shorter the lead time, and therefore redundant communications means have been defined for these periods.

Evacuation routes and centres should be defined in the community. Awareness activities regarding the EWS should be carried out.

5. Landslides

Type of Landslide

Landside risk varies with landslide types. Landslides are often classified with regard to depth and speed. Deep and rapid landslides are most dangerous.

Shallow and rapid landslides can also be dangerous when many landslides occur during the same triggering event. Slow landslides are relatively safe for people since they allow evacuation even during motion. However, often villages are constructed on reactivated landslides (previously landslide occurred and relatively flat areas are provided by past landslide events). The velocity is not so high, and travel distance is not great in this type of landslides. However, landslide movement can be enough to destroy houses, schools, and other buildings. The failure of houses and other structures may give damages to humans. Shallow and slow landslides are relatively not dangerous and they are rarely monitored with EWS. Deep and shallow, rapid and slow movements have different mechanisms, so the same criteria of early warning cannot be applied. In general, risk is very different in urban environment or rural area.

Timing

Lead times for landslides vary depending on the trigger and on the nature of the landslide. Independently of the lead time, we can distinguish two types of EWS for landslides:

- Pre-trigger: a probability of landslide occurrence is based on the analysis and elaboration of precursors. A warning is issued when a threshold is reached but the landslide is not really certain (for example heavy rainfall).
- Post-trigger: a landslide has occurred and the system provides warning for a potentially dangerous future condition (event warning system). For example, an EWS can detect the occurrence of a landslide and can automatically send an evacuation order to the population leaving further down in the valley. However, there is no indication of the final runout and the landslide might end before reaching the inhabited area.

Both types (pre- and post-trigger) can lead to false alarms. When the lead time allows it, a validation procedure should be implemented.

EWSs for landslides are monitoring systems specifically designed to detect events that precede a landslide in time to issue an imminent hazard warning and initiate mitigation measures. The key to a successful EWS is to be able to identify and measure small but significant indicators that precede a landslide, and to issue warnings early enough to allow sufficient lead time to implement actions to protect life and properties. They can therefore be adopted only for very limited goals. The case of rapid landslides is complicate because the time elapsing between the onset of slope failure and its impact on exposed life and properties can be in the order of tens of seconds and landslides may often occur anywhere within wide areas which lack instrumentation able to validate the events. Rainfall forecasts can be used to calculate soil saturation and, as the meteorological event approaches, specifically developed thresholds make use of ground-based rainfall observations to determine overall system evolution in the very short term (nowcasting).

5.1 Landslide EWS Approach

The landslide EWS approach would be similar to the flood one as described above. There is a national level forecasting system based on precipitation thresholds and a local monitoring sensor system. The national forecasting system will provide information about possible landslide events based on previously recorded events and the associated amount of rainfall that trigger the event.

The main objective from a national level point of view would be to support communities. In order to do that, there are several activities planned at this level:

- Maintenance and exploitation of the weather stations database
- Upgrade of existing weather stations to automatic capabilities
- Provision of initial forecasting information to communities and the general public
- Support communities in the deployment, maintenance and operation of the required sensors

From a community-based point of view the following activities are recommended:

- Deployment of required sensors, automatic weather stations, extensometers
- Deployment of communication devices (sirens)
- Implementation of evacuations routes and centre

5.2 Site Selection

One location has initially been selected for the landslide EWS, namely Aituto (Ainaro). This selection has been undertaken after a field visit, after discussions with local representatives and after discussions with NDOC staff. It should be noted that this location can be altered, and that in this section the Aituto site will be presented.

5.3 National Landslide EWS Support

5.3.1 Risk Assessment

Historical information on landslide occurrences is one of the most important considerations in landslide hazard assessment, as this gives insight into the frequency of occurrence, their spatial distribution, the types of landslides that took place, the volumes and the damage that they caused. All these are essential in understanding of the correlation between various causative factors.

As noted in the Deliverable 2 during this consultancy, a national and study area landslide risk assessment was carried out by respectively UNDP and the World Bank. Also, information about previous landslide occurrences is being managed by NDOC. Information about the rainfall associated with this landslides should also be collected for forecasting purposes, as described below.

5.3.2 Monitoring and Warning

The implementation of a National Landslide monitoring and warning service is recommended and suggested. At this stage, a simplistic approach is suggested. This approach can be improved in the future, as suggested in the 'future improvements' section below.

The monitoring and warning Landslide service should be based on rainfall thresholds. Empirical rainfall thresholds are tools to forecast the possible occurrence of rainfall-induced landslides. Accurate prediction of landslide occurrence requires reliable thresholds, which need to be properly validated before their use in operational warning systems. These relations need to be established by a record of landslide-triggering rainfall events. Due to the strong variability of rainfall and soil conditions, it is indispensable to develop a rainfall-landslide relation adapted to the region where the EWS is about to be implemented.

This implementation would involve the following steps:

- Collection of all the required data:
    - Landslide events
    - Soil information
    - Rainfall duration and intensity

- Determine rainfall thresholds

It should be noted that that rainfall is not always directly connected with the landslide occurrence. The transfer function from rainfall to pore pressure and to runoff is not so easy to define and to calibrate, a lot of parameters have to be taken into account for calibrating such as water content, permeability and fracture. A direct link between rainfall event and landslide occurrence can only be efficient in a statistical way, at small scale. However, considering the existing information and the existing technical level regarding the forecasting of landslides, the use of rainfall thresholds is considered to be the best initial approach. Further improvements to this approach are noted in sections below.

5.3.2.1 Definition of Warning Levels

The warning levels described in the flood EWS (section 4.4.2.1) should be used for the landslide EWS (and for any other hazard). This ensures that community members are not confused by different coding for different hazards.

Regarding the criteria for defining the different levels for the landslide hazard, similarly to the flood case, two different approaches should be followed at this stage. In the first case, at national scale, forecast warning based on numerical weather prediction models, should be used. As previously noted thresholds for this should be defined through a risk assessment study. Some examples could be:

	Green	Yellow	Orange	Red
Precipitation Thresholds for Landslides	Less than 50mm in 24h	50mm – 70mm in 24h	70mm – 100mm in 24h	100mm or greater in 24h

Table 2 – Example of different precipitation thresholds for landslide warning purposes

In the second hand, at a community level, threshold levels should be defined using information from the monitors. This will be further described in the community-based EWS section.

5.3.3 Communication and Dissemination

The communication and dissemination of the landslide warning should be carried out in a similar manner as described above for the flood hazard, especially regarding the forecasting information. Regarding the sensor information, as it will be discussed below, the communication system would depend in the choice of extensometer.

5.3.4 Response

The response component from a National Level point of view should have the same features as the flood EWS one.

5.3.4.1 Monitoring During Response

The monitoring during the response can be carried out using the same means as with the flood EWS. In this case, regarding the satellite sources, optical satellites are preferred. Again, it is suggested that an organisation from Timor Leste ask for membership of the International Charter of Space and Disaster. This charter has been activated in the recent years in numerous occasions for landslide post-disaster monitoring purposes.

5.4 Community-based Landslide EWS

As previously stated, the landslide EWS example will be detailed for the Aituto community. The consultant visited this community during this field trip (Figure 19). A landslide event took place in Aituto two years ago after several days of intense rainfall. Several houses were affected. The area around the landslide appears to be susceptible to further landslides providing that the precipitation trigger conditions occur again.

Figure 19 – Aituto previous landslide (red circle)

The consultant identified some other communities suitable for the implementation of a landslide EWS, such as Mosiga or Maubise.

5.4.1 Risk Assessment

It is very important that the selected community understands the associated landslide risk. The risk information available from previous risk assessment studies is a bit coarse for a community approach. It is recommended that more detailed risk assessment at community scale is undertaken. In this risk assessment, area at risk should be identified in maps and this information should be made available to the community members.

It should be noted that landslide hazard maps are not always easy to be understood by local communities. Simplicity of the mapping method and the visualization is the key aspect for ensuring the effective function of the map in supporting the disaster risk reduction program. Also, it is important to allow community participations during the mapping process. The community map could simply prepared and drawn on base-map of the village, showing roads, rivers, houses and land farming areas. In these maps, community members can easily identify the position of their houses, and also be aware about the level of hazard or risk in their living environment.

This produced hazard map will also very important to define the location for the instalment of the early warning instruments and the route for evacuation.

5.4.2 Monitoring and Warning

A more detailed sensor-based EWS is recommended at the community scale. The implementation of such a system is challenging, but the benefits can be significant. The following sensors are proposed (Figure 20).

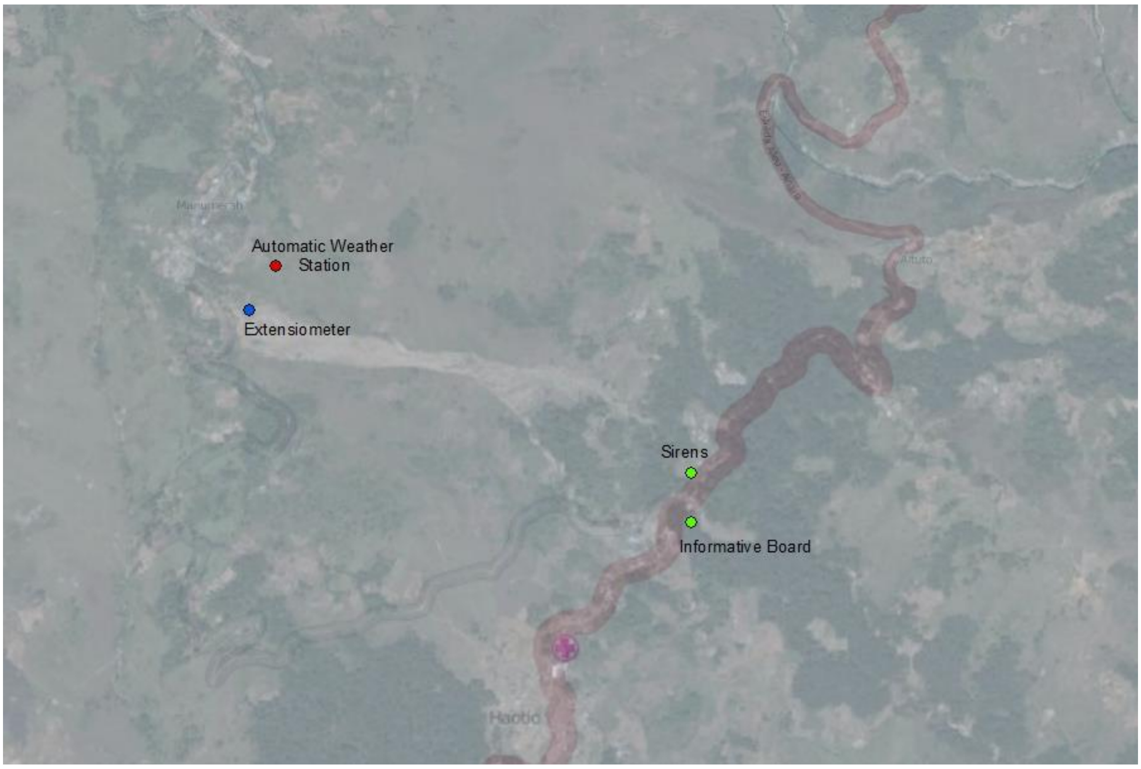

Figure 20 – Aituto Landslide EWS

5.4.2.1 Forecasting

As previously noted, it is recommended that a National Level forecasting for landslide is implemented. This system will initially be based on rainfall thresholds and will provide warnings to the communities whenever these thresholds are surpassed.

5.4.2.2 Automatic Weather Station

An automatic weather station should be deployed uphill of the possible landslide area (Figure 20). Different sensors will be deployed within this station, highlighting the precipitation sensor and the soil moisture sensor. The precipitation sensor will be used for trigger information, being much more reliable and accurate than forecasting information. Also, it can be used for analysis of landslide events in the case that they actually occur. The soil moisture sensor will be used for future implementation purposes. The soil moisture has a direct implication on the trigger of landslide events too. Although the use of these data is not as direct as the precipitation one, it is suggested that capacities are developed for its use. Therefore, it is recommended that this data is being initially recorded and collected.

5.4.2.3 Extensometer

Extensometers measure displacement. They detect the movement of ground relative to cracks/fractures horizontally, where the installation is performed in a crack or in critical areas.

Simple mechanical extensometers use a steel wireline firmly connected to a fixed location on the slope face on one end and to a track-mounted weight, located off the slide, on the other end. Movement of the slope pulls the weight along the graduated track. The amount and rate of movement can then be measured manually (Figure 21).

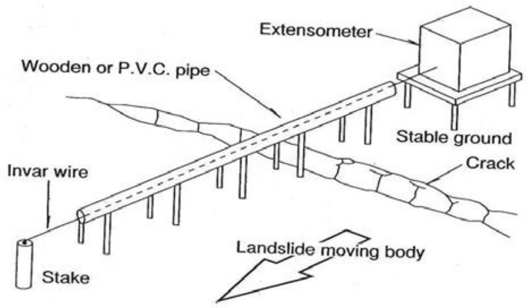

Figure 21 – Manual Extensometer

It is recommended that at least a manual extensometer is installed in the community. The manual extensometer can be directly connected to a siren system, a whenever a certain displacement threshold is surpassed the siren is activated. This way, the need for the direct intervention of a national level organisation is not required. Some training is obviously required, and the deployment should be undertaken by a highly qualified organisation. However, the fact that a manual-mechanical extensometer can be easily operated by the community members and directly alert the community, makes them a very useful tool.

There are also automatic extensometers (Figure 22). These extensometers are digital and when telemetry capabilities are provided, can directly send information and data to the operational centre. Warning thresholds and/or a data-logger can be provided too. This extensometers are more reliable and can send important information about displacement dynamics. However, they are more expensive and the community will not be able to, directly, get information about a displacement uphill.

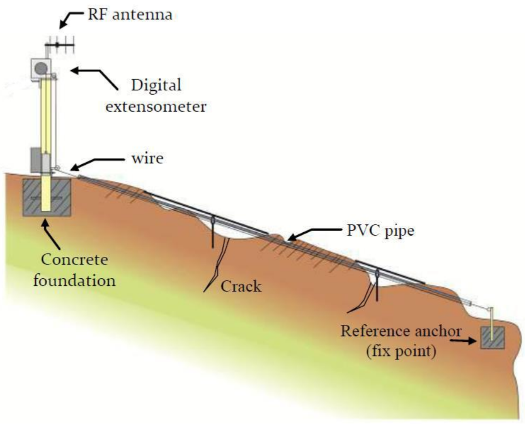

Figure 22 – Automatic Extensometer

5.4.2.4 Tiltmeters

At this stage the deployment of an automatic weather station (rainfall and soil moisture measurements) and a manual extensometer is recommended. There are more sensors available for landslide monitoring, such as tiltmeters or inclinometers. Inclinometers or tiltmeters can detect new movement, an acceleration of movement and the direction of movement. They can send data wirelessly. The deployment and battery consumption of these devices posed some issues, and at this stage the deployment of tiltmeters is not entirely recommended. Initially it is recommended that a more basic system is deployed and then upgraded in the near future once the success of the initial scheme has been proven.

5.4.2.5 Monitoring and Warning System Summary

The whole monitoring system for the landslide warning system can be observed in Figure 23. If the precipitation from the forecasting system or from the automatic weather stations surpasses the pre-defined threshold, a warning to the communities will be sent. As detailed, the forecasting system and the automatic weather stations will be managed by the NDMG. The warning produced by the manual extensometer will directly activate sirens in the community. The community leader(s) in charge of the system will be in charge to inform the focal NDOC point of the activation of the sirens and the impending warning.

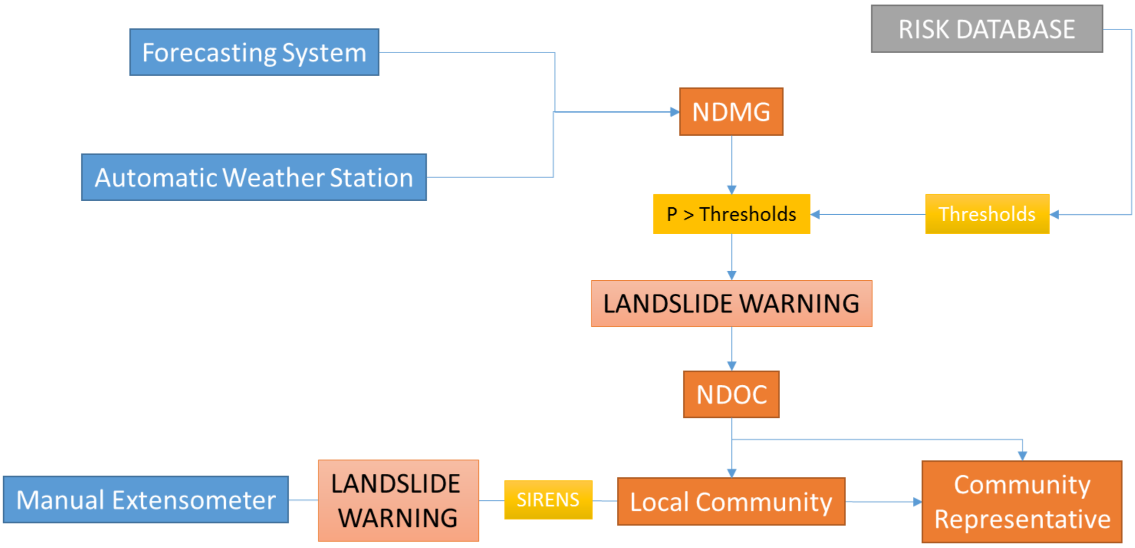

Figure 23 – Aituto Landslide monitoring and warning system

The sequence of the different type of warnings can be observed in Figure 24. The forecasting system will warn about the possibility of a landslide happening with at least 24 hours in advance. The automatic weather station will provide information about the actual precipitation in the study area, and will provide more detailed and accurate information about the possibility of an impending landslide. The extensometer will provide information about a landslide already occurring.

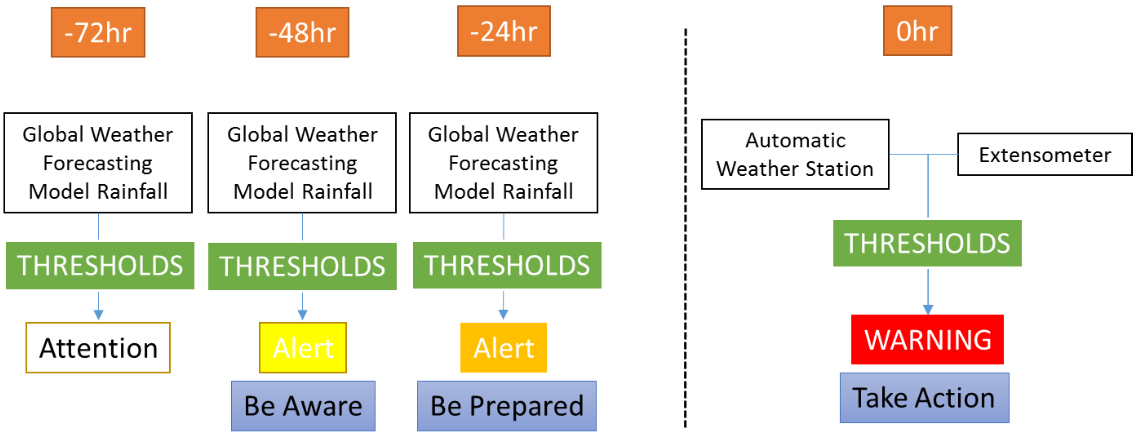

Figure 24 – Aituto Landslide monitoring and warning system

5.4.2.6 Definition of Warning Levels

The criteria for the definition of the warning levels will be based on a risk assessment, as previously detailed. Regarding the extensometer displacement, the values outlined in Table 3 can initially be used.

	Green	Yellow	Orange	Red
Landslide from Extensometer	No displacement	Displacement of less than 2cm	Displacement of 2cm-5cm	Displacement of more than 5cm

Table 3 – Example of different precipitation thresholds for landslide warning purposes

5.4.3 Communication and Dissemination

The communication and dissemination of the warning should follow more or less the same principles as outlined for the flood EWS. In this case, a couple of distinctions should be noted.

5.4.3.1 Sirens

In this case, sirens will be automatically activated once the extensometer threshold has been surpassed. Therefore, the community representatives should inform the NDOC focal point about this activation.

It should be noted that a visual inspection should be undertaken after the siren activation to corroborate that the landslide has already started. This could be accomplished in the near future if cameras are installed.

5.4.4 Response

The response component for the landslide EWS from a community point of view should follow the same guidelines as the ones established for the flood EWS.

6. Strong Winds

Strong winds in Timor Leste can be the result of formal cyclones or normal strong wind events.

Timor-Leste is situated in a cyclone belt where increased storm activities can be expected. Besides cyclones, Timor-Leste is affected annually by tropical storms. These tropical storms can be as devastating as a cyclonic activity as they can deposit extremely high amounts of rainfall in a short time period. Tropical cyclones can affect Timor-Leste between November and April; however their effect tends to be weak. In the 41-year period between 1969 and 2010, 31 tropical cyclones passed within 400 km of Dili, an average of less than one cyclone per season.

There are several seasons for strong winds, usually tied up to the monsoon conditions. The country is affected by two sets of monsoonal conditions: the Northwest (wet monsoon) that brings storms and flooding, and the Southeast (dry monsoon) that brings strong winds to the south of the island. Additionally, as previously noted, the strong winds associated with tropical cyclones as well as localised wind events (mini-tornadoes) often damage weak housing structures and installations; electricity poles; agricultural crops such as rice and corn; etc., which in turn affect the livelihoods of the people in the region. Strong winds in Timor-Leste usually occur between March-April and between September-October.

6.1 Strong Winds EWS Approach

The strong winds EWS approach, regarding the monitoring and warning, it is based on the use of forecasting information from NWP and local monitoring data. There is an obvious link between the EWS for strong winds and the existing information that NDOC receives from the Tropical Cyclone Centre in Darwin.

It is advised that the main role for this monitoring and warning falls within the national level. Strong winds cannot be predicted in advanced using information from monitoring devices installed at communities. However, the deployment of automatic weather stations is recommended. This is in order to both verify and validate information received from NWP sources and also because most automatic weather stations deployed have other purposes in addition to strong wind monitoring.

The main early warning source, as previously noted, will be Numerical Weather Predictions (NWP) models.

6.2 Site Selection

The communities of Ainaro, Cassa and Aituto have initially been selected for the strong wind EWS. As it can be observed in the strong wind risk assessment below (Figure 25), all these three communities lie within the high hazard area for strong winds.

It should be noted that, although in Aituto the main emphasis is the landslide hazard, the EWS infrastructure deployed for this hazard can be easily utilised for the strong wind hazard. Also, because the monitoring and warning component for the strong wind hazard falls mainly within the national level, using these resources for this hazard in Aituto is not a difficult task. The same applies for the fire hazard in most cases. Nevertheless, the type of hazards used in every community, or even the communities to target (as previously noted), can be easily adjusted.

6.3 National Strong Winds EWS Support

6.3.1 Risk Assessment

A strong wind assessment was carried out by the World Bank in the Dili-Ainaro Road Corridor (Figure 25). This assessment was carried out using the WRF meteorological model. The UNDP risk assessment project also undertook a strong risk assessment for the whole Timor Leste.

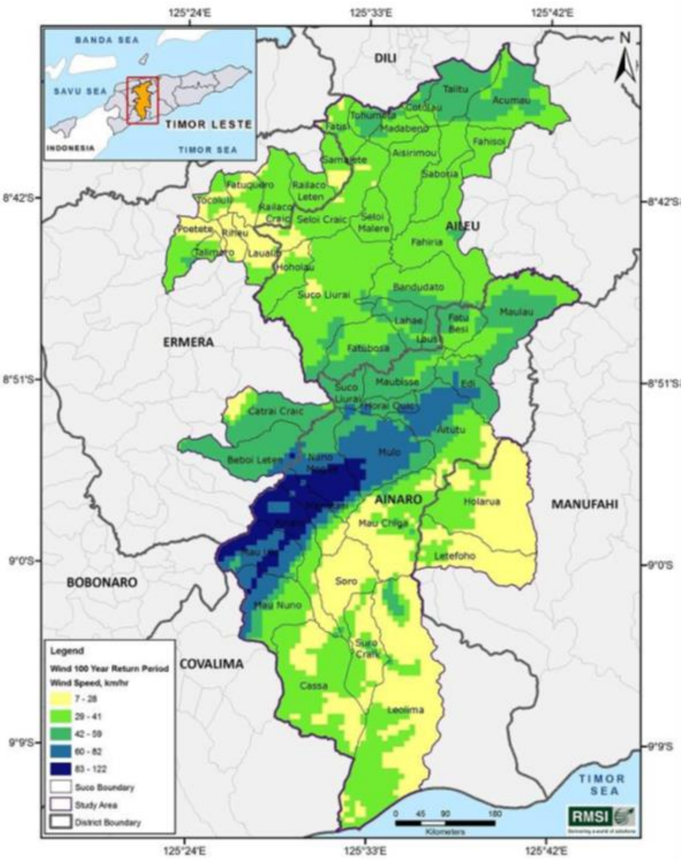

Figure 25 – Strong Wind Risk Assessment in the Road Corridor (World Bank project).

It is recommended that NDMG starts developing capabilities for meteorological modelling. It would be ideal if NDMG can take ownership of the WRF model used for the risk assessment by the World Bank. This could lead to more detailed assessments in the study area and the selected communities and also to the operational use of the NWP model as detailed in the future improvements section (13.1)

6.3.2 Monitoring and Warning

As previously noted, the monitoring and warning will be mainly based on information from meteorological forecasting models (NWP). It should be noted that the same forecasting model can be used for both the precipitation forecasting and the wind forecasting. Meteorological forecasting models usually can provide different variables, including precipitation and wind speed and direction.

Also, the deployment of automatic weather stations is recommended in each of the communities selected for the strong wind scheme. This will provide a more accurate wind information than the forecasted one. It should be noted, that wind forecasting information is usually fairly accurate, especially if assimilation processes are implemented. The station data could be used for assimilation purposes too.

It should be added that the information about strong winds can come from two different sources. It come be the result of the NDMG analysis of the NWP for the next days or it can be directly the result of a warning by the Tropical Cyclone Centre in Darwin. In either case, the NWP should be able to predict both pure strong wind events and cyclones. The only difference would be that in the latter case, there will additional warnings from the centre in Darwin. Nonetheless, the NDMG should implement mechanisms for identifying events with predicted winds over a certain thresholds.

6.3.2.1 Definition of Warning Levels

Initial threshold values are suggested for the strong wind forecasting (Table 4). More information about strong wind threshold levels should be collected from previous events and these values could be adjusted.

	Green	Yellow	Orange	Red
Strong Wind	Gusts less than 80 km/h	Mean Speeds between 50 and 65 km/h	Mean Speeds between 65 and 80 km/h	Mean Speeds in excess of 80 km/h
		Gusts between 90 and 110 km/h	Gusts between 110 and 130 km/h	Gusts Speeds in excess of 130 km/h

Table 4 – Example of different wind speed thresholds for warning purposes

6.3.3 Communication and Dissemination

The communication and dissemination component at National Level should follow the same procedures set up for the flood EWS.

6.3.4 Response

The response component at National Level should follow the same procedures set up for the flood EWS.

6.4 Community-based Strong Winds EWS

As previously noted, several communities have been initially selected for the implementation of the wind EWS. In this case, the Ainaro case would be presented in more detail.

6.4.1 Risk Assessment

A more detailed risk assessment should be carried out in all the communities participating in the strong wind scheme. The participation of community members should be significant and the depicted risk assessment maps should be clear enough for the community. Information from this assessment should be distributed to the whole community and the information posted in dedicated boards.

6.4.2 Monitoring and Warning

The main monitoring and warning devices implemented within the communities should be automatic weather stations with wind speed, gust speed and wind direction sensors. These sensors should be deployed at 10m following the WMO standards. Also, the automatic stations should have telemetry capabilities in order to allow for these data to be automatically transferred to the NDMG. The stations can be also deployed allowing for warning messages to be sent to the operational centre whenever certain thresholds have been surpassed. Nonetheless, NDMG should implement automatic mechanisms for the identification of values over a certain pre-defined threshold.

The location of the automatic weather stations should be taken carefully. Vandalism issues should be considered. Also, the station should be located in an open area with no surrounding trees. An assessment should be undertaken in each location in order to find the most representative and suitable location.

It should be noted that, for instance, in Ainaro there are traditional monitoring mechanisms that should also be considered. Traditional monitoring means are in place because they have been useful in numerous occasions. In this case, it seems that in Ainaro, whenever it is observed that the river surface water becomes whiter, strong winds occur. The reasons for this are not clearly understood by the consultant, but this knowledge and monitoring process should not be dismissed and used for validation purposes too.

It should be added, that even if wind forecasting information is fairly accurate, there can be strong wind events that have not been predicted by the forecasting system. In this case, the station information and the change in the water colour could be used to set up a warning.

6.4.2.1 Definition of Warning Levels

The definition of the strong wind warning levels should be the same as in the National level one.

6.4.3 Communication and Dissemination

The communication and dissemination procedure should follow the same procedures set up for the flood EWS. In this case, forecasting information and information from deployed automatic stations are also used, and therefore the warning timing and the communication procedures should be the same.

6.4.4 Response

The response component for the strong wind EWS from a community point of view should follow the same guidelines as the ones established for the flood EWS.

It should be noted that, as a precaution, during strong wind events in Ainaro, the electricity network is stopped to prevent damages. The fact that forecasting information will be used within the EWS allows for better preparedness regarding this.

7. Fire

The current state of the forests of Timor-Leste is unknown as there has been no recent national forest resource inventory and the establishment of the forestry data collection process in Timor-Leste is still in its development stage. Although there has been several initiatives by the government of Timor Leste to maintain and replant the forest, the threat of forest fires is still high in some areas. Forest fires can be ignited by lightning or other natural causes but human influence is also significant, especially in Timor Leste, where fire is commonly used to clear land for agriculture. Fires can burn uncontrollably during dry periods, destroying vegetation and crops.

The causes of the forest fires can be classified into three main categories:

- Natural causes
- Intentionally/deliberately caused by man.
- Unintentionally/accidently caused by man.

The main wildland fire problems in South East Asia are related to traditional shifting cultivation, land clearing fires, especially in converting native forests and peatland biomes to plantations, and uncontrolled wildfires in rainforests, peat-swamp forests, monsoon forests and mountain pine forests. High fire activities usually occur during dry spells and droughts caused by the El Niño-Southern Oscillation (ENSO) phenomenon.

Regarding the type of wildfires, there are three different classes:

- Surface fire: is the most common type and burns along the floor of a forest, moving slowly and killing or damaging trees.
- Ground fire: is usually started by lightning and burns on or below the forest floor in the human layer down to the mineral soil.
- Crown fires: they spread rapidly by wind and move quickly by jumping along the tops of trees.

7.1 Fire EWS Approach

Early warning systems for fire management for local, regional, and global application require early warning information at various levels. Information on current weather and vegetation dryness conditions provides the starting point of any predictive assessment. From this information the probability of risk of wildfire starts and prediction of the possibility of current fire behaviour and fire impacts can be derived. Short- to long-range fire weather forecasts allow the assessment of fire risk and severity within the forecasting period. Advanced space borne remote sensing technologies allow fire weather forecasts and vegetation dryness assessment covering large areas (local to global), at economic levels and with accuracy which otherwise cannot be met by ground-based collection and dissemination of information. Remote sensing provides also capabilities for detecting new wildfire starts, monitoring ongoing active wildfires, and, in conjunction with fire-weather forecasts, providing an early warning tool for escalating, extreme wildfire events.

Therefore, the implementation of a fire early warning system at either national or local scale appears to be really complicated at this stage. The use of satellite sources is required for the implementation of this system, and considering the complexity associated to the processing of earth observation data, it is recommended that at this stage that Timor Leste organisations make use of existing global and regional fire danger resources.

Also, earth observation resources will be used for the response-monitoring component, especially products from the MODIS satellite.

The implementation of a fire danger – EWS system is recommended in the future improvements section. The Canadian Wildfire Danger system is the most widely used and the recommended one. Due to the nature of the EWS designed, there are no specific requirements regarding the communities chose for the implementation. Initially, Cassa, Aissirimou and Ainaro have been selected. The community network created for the implementation of the previous hazards can be used for the fire hazard.

7.2 National Fire EWS Support

7.2.1 Risk Assessment

The only significant forest or wild fire risk assessment carried out for Timor Leste was carried out by UNDP and at a National scale (Figure 26). There are no specific risk assessment for the Road Corridor area. It is recommended that a more detailed assessment is carried out for the Road Corridor area.

In addition to that, it is recommended that the following information is made available and/or collected:

- Previous wild fire events in Timor Leste (or the study area).

- All the information available regarding these previous events. In the case of natural events, information about previous conditions should be collected.
- Information about vegetation cover for the whole Timor Leste territory (or for the study area).

The information for the risk assessment exercise, as with all the different hazards, should be made public and distributed to the general public for risk awareness purposes.

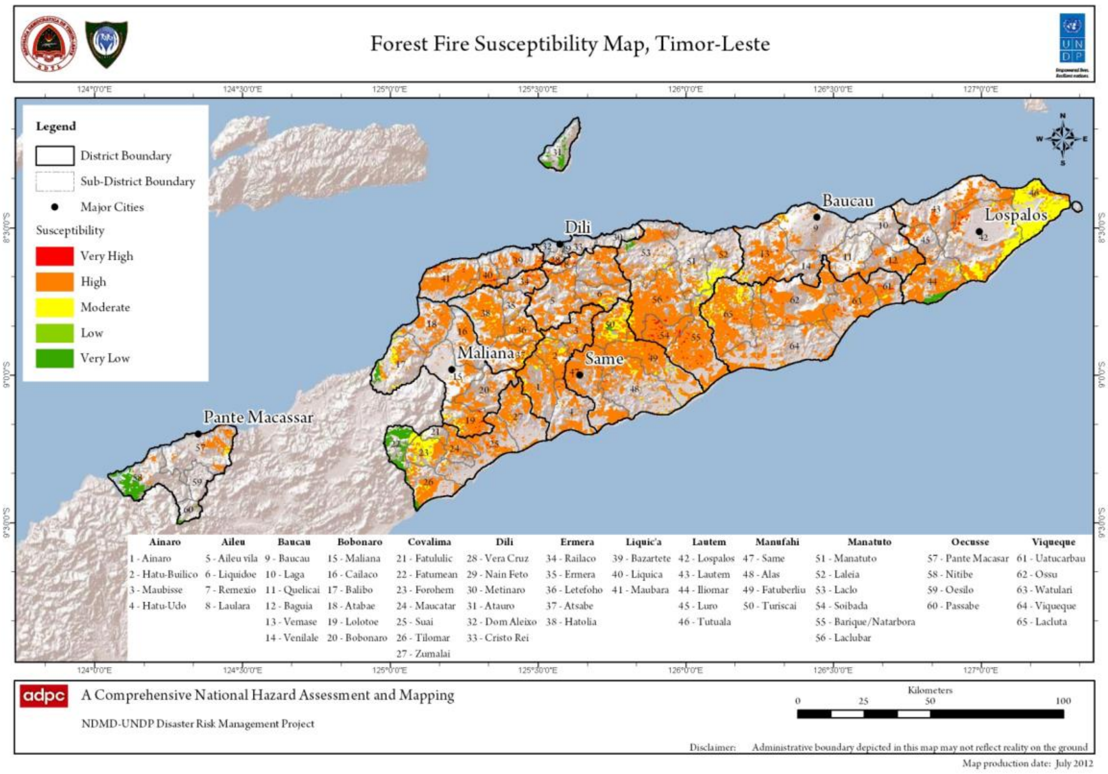

Figure 26 – Forest Fire Risk Susceptibility Map for Timor Leste (UNDP project).

7.2.2 Monitoring and Warning

The monitoring and warning component will be based on the two different initiatives, namely the 'Global Early Warning System for Wildland Fires' and the 'Fire Danger Rating System (FDRS) for Southeast Asia'. Both systems use as main indicators products from the Canadian Forest Service.

Obviously, local communities will play a major role in the fire detection. Whenever a forest fire is detected, it is expected that NDOC focal point, District Administrators and firefighters are informed immediately. Subsequently, NDOC will be informed by the NDOC focal point in order to coordinate the response.

7.2.2.1 Global Early Warning System for Wildland Fires

The Global Early Warning System for Wildland Fires was developed by the The Global Fire Monitoring Center in the Freiburg University / United Nations University and the Canadian Forest Service. The system is operational and maintained by the Freiburg University.

The fire danger indicators currently presented on the Global Early Warning System for Wildland Fire (Global EWS) are components of the Canadian Forest Fire Weather Index (FWI) System.

The Global EWS provides 1-7 day forecasted FWI System data based on the NCEP Global Forecast System (GFS numerical weather predictions by the North American Oceanic and Atmospheric Administration (NOAA)). The FWI System components are currently calibrated to commonly used threshold values that identify low to extreme conditions. The 1-7 day forecast identifies the expected future fire danger trend.

It should be noted that the Global EWS should be applied with care at local level. This is because the influences of fuel, ignition sources, climate and fire management/suppression policy are not fully considered. A regional calibration would be required in order to make this product much more useful at local scale.

The FWI System has 6 components that represent fuel dryness and potential fire behaviour at the landscape level.

- Fire Weather Index (FWI) is a general indicator of fire danger and fire intensity (Figure 27)
- Buildup Index (BUI) indicates dryness of medium and large dead fuels
- Initial Spread Index (ISI) is an indicator of rate of fire spread
- Drought Code (DC) indicates dryness of deep, compact organic layers in the forest floor
- Duff Moisture Code (DMC) indicates dryness of loosely compacted, upper organic layers of the forest floor; often used as a predictor of lightning-caused fires
- Fine Fuel Moisture Code (FFMC) is an indicator of the dryness of dead fine fuels; often used as a predictor of human- and lightning-caused fires

The main product to be used in this case would be the Fire Weather Index. The lack of regional calibration and the horizontal resolution (limited by the GFS NWP resolution of 0.5 degrees) pose some issues.

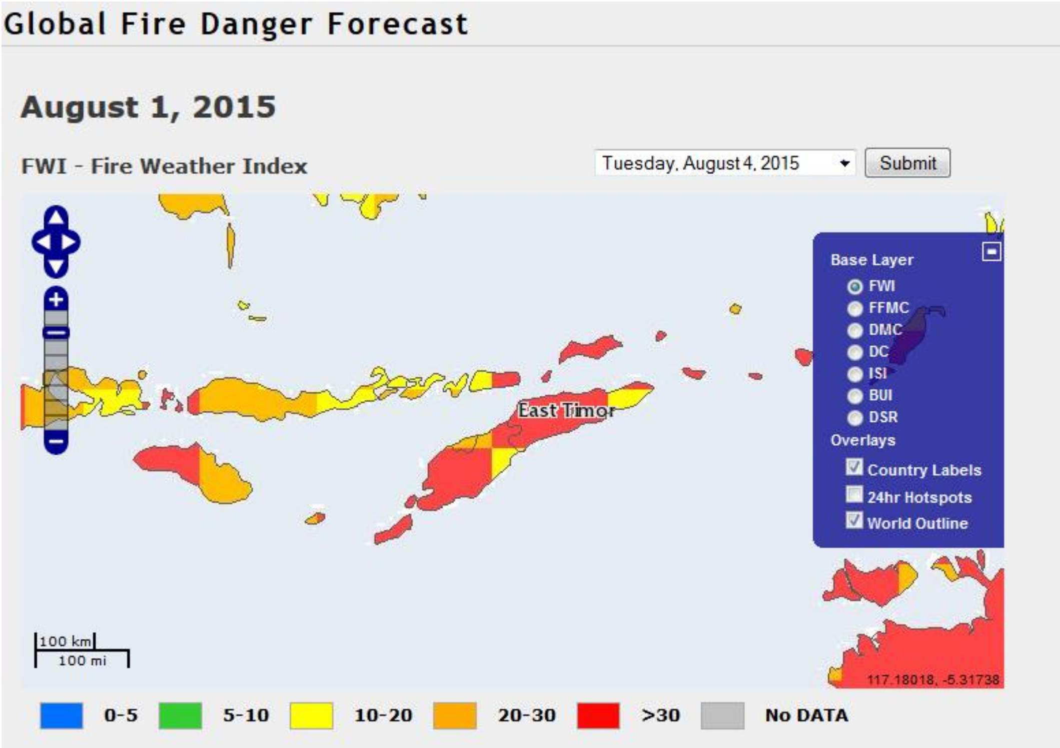

Figure 27 – Fire Weather Index example forecast for the Timor Island

7.2.2.2 Fire Danger Rating System (FDRS) for Southeast Asia

The Fire Danger Rating System (FDRS) is also based on the Canadian Fire Weather Index System. Actually, the implementation of this system in the Southeast Asia region was carried out by the Canadian Cooperation Agency, and the Canadian Forest Service.

This service was implemented in the Malaysian and the Indonesian Meteorological departments, and the operational information is available there. The products available in this service are exactly the same as the products available in the previously described Global Fire EWS, because both of them are based on the same index and system. In this case, the product has been calibrated for regional use, and therefore it is believed that this system is more useful for Timor Leste.

Information from this system is available through the Malaysian Meteorological Department both in jpeg (Figure 28) and Google Earth (Figure 29) format. The main issue with this system would be the existing resolution and the fact that just one day of forecast information is available online. It is recommended that the NDMG develop links with either the Malaysian or the Indonesian Meteorological Departments for the direct provision of these data.

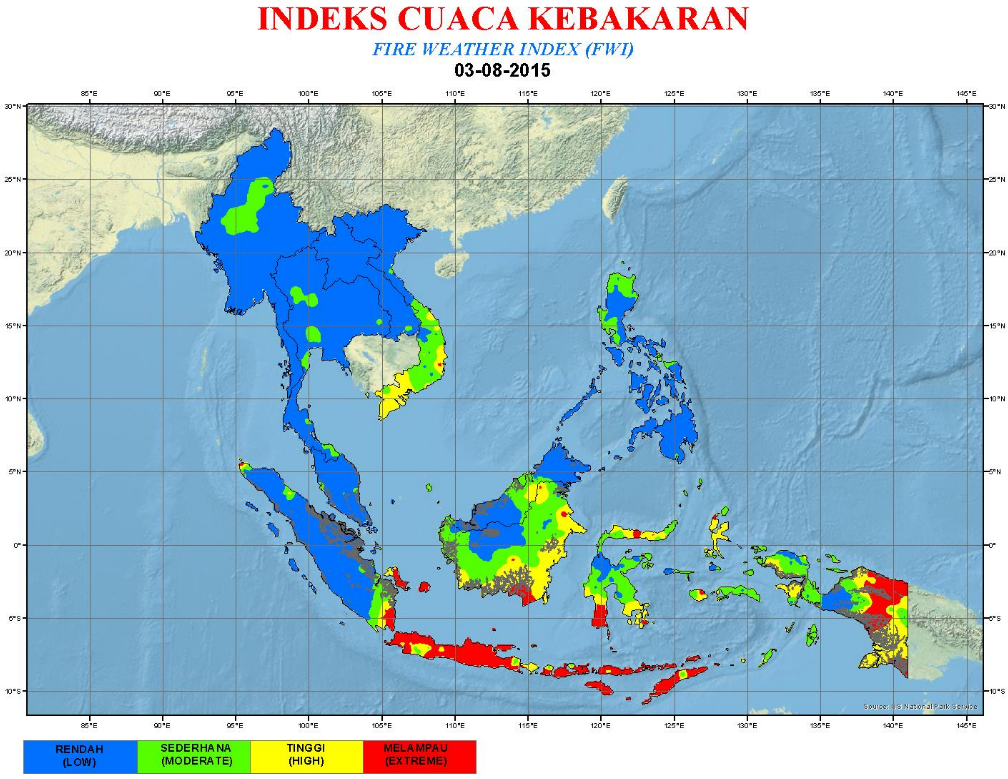

Figure 28 – Fire Weather Index example forecast for Southeast Asia

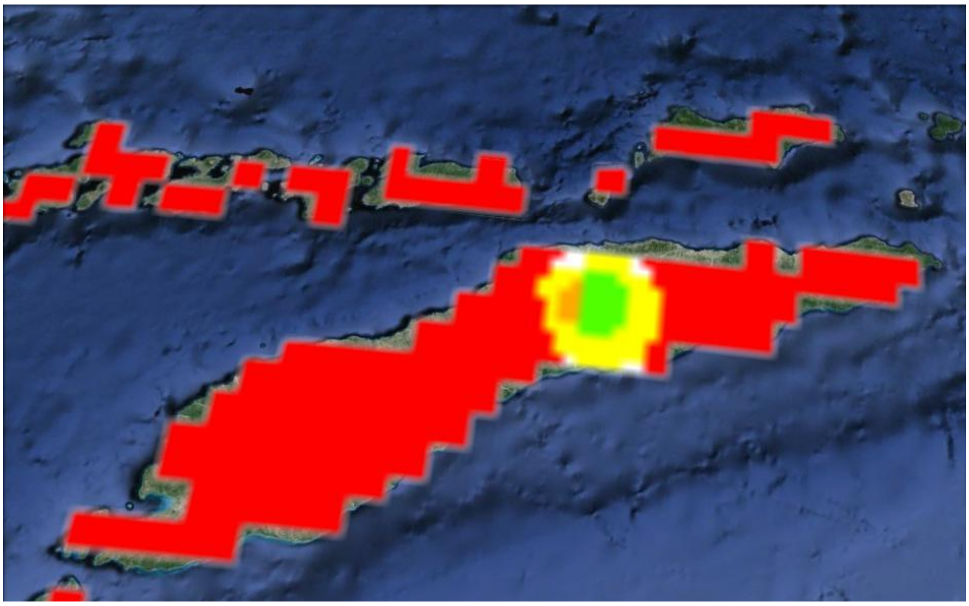

Figure 29 – Fire Weather Index example forecast for the Timor Island for the 3rd of August (Google Earth)

7.2.2.3 Definition of Warning Levels

Unfortunately, the pre-defined warning levels (Table 5) for the Fire Danger Rating System (FDRS) for Southeast Asia system are different to the previously defined warning levels for flood, landslide and strong winds.

	Low	Medium	High	Extreme
Fire	Low fire intensity. Fire will spread slowly or be self-extinguishing. Grassland fires can be successfully controlled using hand tools.	Moderate fire intensity in grass. Hand tools will be effective along the fire's flanks, but water under pressure (pumps, hose) maybe required to suppress the head fire in grasslands.	High fire intensity in grass. Direct attack at the fire's head will require water under pressure, and mechanized equipment may be required to build control lines. (e.g: bulldozer)	Very high fire intensity in grass. Fire control will require construction of control lines by mechanized equipment and water under pressure. Indirect attack by back-burning between control lines and the fire may be required.

Table 5 – Existing fire warning levels

It is suggested that once the NDMG receives this information directly and/or after a local implementation, the colour-coding and the warning levels are changed to the initially suggested ones for all the remaining hazards.

7.2.3 Communication and Dissemination

The communication and dissemination component for the fire hazard would differ slightly for the three previously explained hazards. In this case, after the information from the Fire Danger Rating System (FDRS) for Southeast Asia is received (or collected) by NDMG, whenever high (yellow) or extreme (red) danger is predicted in the relevant area, communities should be informed (by mobile phone) of this danger (Figure 30). This information should be posted in dedicated boards, informing community members about the danger of undertaken certain activities. In this case, it is recommended that the usual warning level (yellow, orange and red) is used.

As previously noted, whenever a forest fire is detected, the relevant local authorities (NDOC focal point, District Administrators and firefighters) should be immediately notified.

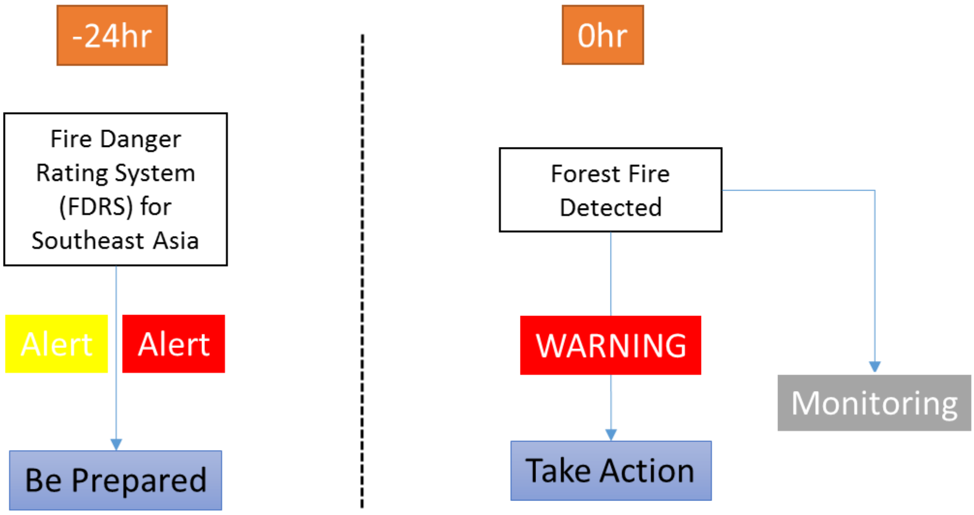

Figure 30 – Forest Fire Communication.

7.2.4 Response

As indicated in the communication figure above (Figure 30), one of the most critical steps during the response component would be the acquisition of monitoring images regarding the fire veracity and extent.

There are several resources regarding forest fire monitoring from satellite sources. The MODIS Land Rapid Response System should especially be noted. This information is open to the public and it can be consulted rapidly and easily by relevant organisation in Timor Leste.

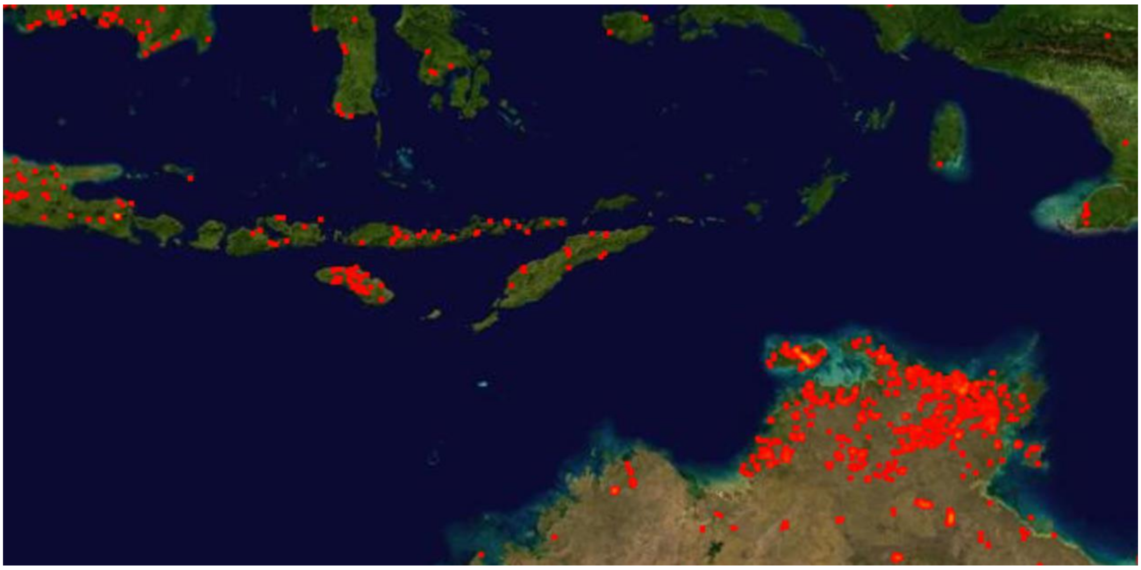

Figure 31 – Forest Fire information from MODIS Land Rapid Response System.

MODIS fire location data are distributed in a variety of forms (e.g. interactive web mapper, GIS, Google Earth, text files) through the Fire Information for Resource Management System (FIRMS) at the University of Maryland. The MODIS Land Rapid Response system has been developed to provide rapid access to MODIS data globally, with initial emphasis on 250m colour composite imagery and active fire data. The system allows a quick real-time search for daily land and fire observation products (http://rapidfire.sci.gsfc.nasa.gov/realtime/).

7.3 Community-based Fire EWS

The establishment of the community-based Fire EWS would follow a different pattern than the other three hazards. It is very difficult to establish a full community based system for forest fires, and the monitoring and warning component it not relevant in this case. The main emphasis in this case should be on community-based preventive measures, on the support on education and sensitization of communities to manage fires and on the use of a community base fire management approach.

A Community Based Fire Management approach could have the following features:

- Analysis: it is important that communities analyse the systematic and integrated collection of data regarding the number, location, size, etc. of fires. This will lead to the development of an understanding of their causes; and also to the analysis of appropriate prevention, response, restoration and rehabilitation action.
- Prevention: communities should develop strategies for preventing and managing unwanted fires, and controlling fire for use in sustainable land management practices
- Preparedness: the training of personnel, the installation and maintenance of required infrastructure, the monitoring of land and weather conditions, the training on the use of the Fire Weather Index, and other activities can enable fire management on a continual basis.
- Suppression: the communities should receive training on actions that can be taken to contain fire and prevent it from spreading, including fire breaks and removal of fuel.
- Restoration: the repair, replacement and rebuilding of physical and ecological assets

A community based Fire management approach enhances the positive role that local communities can play in fire management. It is an approach to the management of fire in the landscape that adequately includes communities in decision-making about the role, application and control of fire. The main results for a successfully implemented community fire management system are:

- It creates sensitivity, awareness and knowledge about fire and the use of fire to improve natural resources income;
- It enable communities to manage fire for their own benefits (as by using prescribed burning) and minimize the negative impacts of fire (such as by constructing fire breaks and engaging in low-cost maintenance)
- It enable communities to develop, regulate and enforce village fire regulations, and to suppress unwanted fires through village fire crews (including the provision of basic fire suppression training and equipment).

By enabling local people to build upon their knowledge and expertise related to fire control and prevention, the potential avenue for effectively managing the wildland fires is created.

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It is important to note, however, that communities cannot provide the complete solution to harmful wildland fires. In this case, the role at a National Level it is slightly more significant.

8. General Recommendations

8.1 Data Management

A proper management system of all the collected and produced data should be designed prior to the implementation of the system. A successful data management system will help in the operation of the system. It should be noted that the different format and dimension of all the data collected and/or produced required a careful planning.

- Satellite data: satellite data is usually provided in GRIB(2), HDF or netCDF format. A THREDDS (Thematic Real-time Environmental Distributed Data Services) data server is proposed for the proper management of these data. The benefits from the implementation of a THREDDS data server are numerous:
    - 4D capabilities
    - Dataset Inventory Catalogues: used to provide virtual directories of available data and their associated metadata. These catalogues can be generated dynamically or statically
    - Web-server capabilities: data from THREDDS can be served as WMS, WCS (OGC standards) easily to any implement web-based application.
    - Data can be easily accessed through OPeNDAP or HTML protocols, including sub-setting.

- Numerical Weather Prediction Data: the same THREDDS data server should be used for all the 2D, 3D or 4D data, especially in netCDF, GRIB or HDF format. Weather forecasting outputs are 4D and are usually provided in either GRIB or netCDF format

- Monitoring Network Data: a SOS database is proposed for the management of all the 1D data, especially data from monitoring stations. SOS (Sensor Observation System) is part of the SWE (Sensor Web Enablement system) an OGC standard and is a service by which a client can easily obtain observations from one or more sensors/platforms. Clients can also obtain information that describes the associated sensor. This service provides an application programming interface (API) for managing deployed sensors and retrieving sensor data and specifically “observation” data. Used in conjunction with other OGC specifications, the SOS provides a broad range of interoperable capability for discovering, binding to and interrogating individual sensors, sensor platforms, or networked constellations of sensors in real-time, archived or simulated environments.

The implementation of such a database requires the previous implementation of a PostgreSQL (with PostGIS capabilities) database. Data exchange is undertaken through XML protocols and, as with the THREDDS case, data can be easily included in any developed web-application.

- Warning data: information regarding warning events is already managed by NDOC through two different platforms, as detailed in the Deliverable 2 of this consultancy.

The implementation of the data management system should be planned carefully, and especial attention should be paid to the information collected from the monitoring network. The collection of these data requires significant efforts, both from a human resources and financial point of view, and therefore it is recommended that the implemented database prevents any data loss and also ensures that data is properly used and managed. It is advised that data management capacities are enhanced in order to ensure this. The servers and external hard drives detailed in the budget section (**Error! Reference source not found.**) should be used for data management purposes too.

8.2 International Charter of Space and Major Disaster

It is highly recommended that a Timor-Leste organisation request membership for the 'International Charter of Space and Major Disaster'. The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorised Users. Authorised organisations without a country are usually national civil protection, rescue, defence and security bodies.. Otherwise, the Charter can be activated via the Asian Disaster Reduction Centre.

The Charter can provide very fast information about most natural disasters including floods, fires and landslides to any authorised user (Figure 32).

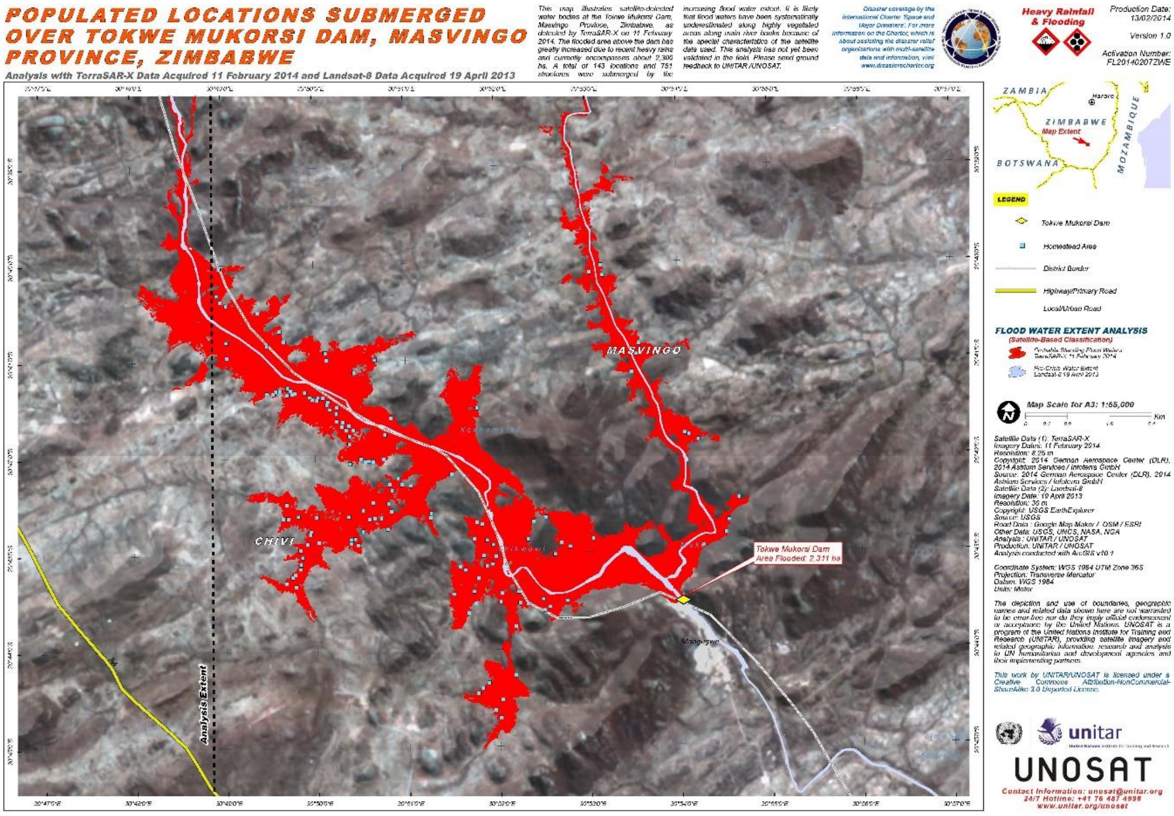

Figure 32 - Example of International Charter of Space and Major Disaster (Zimbabwe February 2014)

8.3 Satellite-Based Antenna

There are numerous EWS worldwide using satellite stations as the main data receiver. The main advantage of these stations is that it does not require internet connection to download or to send data. Thus, this is especially useful in countries where internet connection is not entirely reliable and/or fast, such as Timor-Leste. There are several systems sending satellite data, such as the EUMETSAT (EUMETCAST) or the CMA (CMACAST) systems.

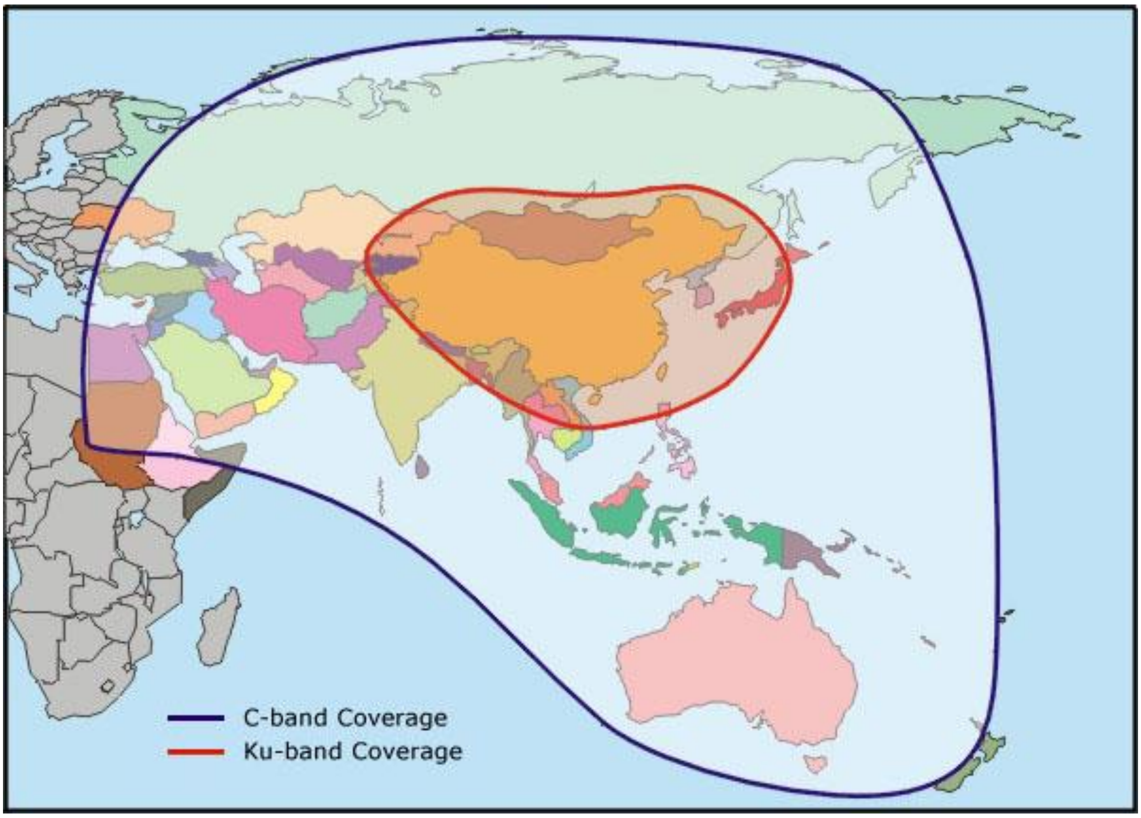

Figure 33 – CMACAST coverage

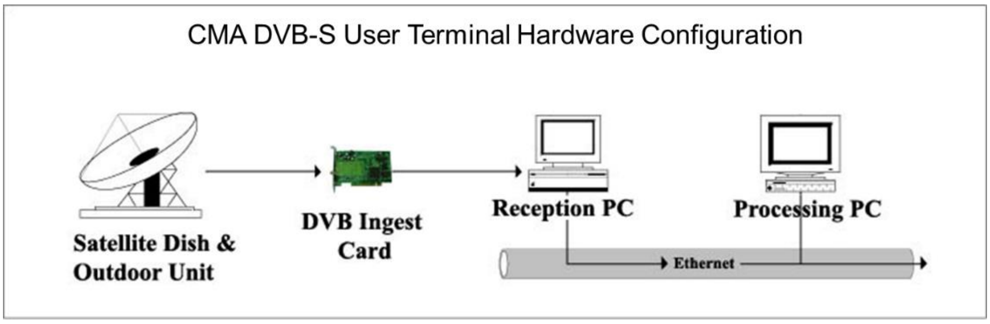

Figure 34 – CMA Configuration

The CMACAST antenna is the evolution of the FengyunCast one and it is being used in numerous countries in the Asia-Pacific region. Some of the data that can be received directly in this antenna are shown in Figure 35.

Category	Data and products	Timeliness
GTS data	Warnings Warning for tropical cyclone, tsunami, tornado, severe thunderstorm, volcanic ash clouds …	10 seconds
	Observations SYNOP; TEMP; PILOT; SHIP; BATHY; BUOY; CLIMAT; AIREP; AMDAR; TRACKOB; TESAC; WAVEOB; SATEM; SARAD; and SATOB.	1 minute
	Model Products ECMWF, EDZW, RJTD, KWBC	20 minutes
	Fax charts BABJ, EDZW, RJTD	5 minutes
CMA Products	Model products T639G, T639R,GRAPES products	20 minutes
	Satellite data FY-2D/E images and products, FY-3A L1 product	10 seconds
Others	Satellite data from EUMETSAT MSG,METOP-A, METOP-B, NOAA19, JASON2	10 seconds

Figure 35 – CMACAST data availability

Through a single satellite antenna images from a number of weather satellites can be received.

CMACAST is developed by the Chinese Meteorological Administration. It is an integral part of a global earth observational data sharing network called GEONetCast. CMACAST re-broadcasts data from various weather satellites over the Asia-Pacific region, including the Fengyun-1 and Fengyun-2 series of satellites of China, the Multi-functional Transport Satellite-1R (MTSAT-1R) of Japan, as well as the National Oceanic and Atmospheric Administration (NOAA) series and the Earth Observing System series of satellites of the USA. The latest weather satellite in the Chinese Fengyun-2 series, viz. FY-2D, and the existing FY-2C satellite are both geostationary weather satellites capable of capturing images over the Asia-Pacific region. During the rainy season, each of the two satellites increases the frequency of observation from once an hour to twice an hour. The two satellites together provide one satellite image every 15 minutes. This is very useful for monitoring such hazardous weather as tropical cyclones and rainstorms, contributing towards the prevention and mitigation of disasters. Also, data from Numerical Weather Predictions models, such as the European ECMWF, can easily be received by the station.

It should be noted that the average price for setting up a satellite receiver station with CMACAST possibilities (in C-Band) is around 4,000USD.

9. Implementation Planning

The implementation of the EWS should follow the following stages

10.1 Inception Phase

Prior to the implementation of an early warning system, an inception phase should be carried out. The main objective of this task would be to compile a report containing the following:

10.1.1 Programme

A Project Implementation Programme describing the required design and implementation tasks of the EWS should be undertaken. Milestones should be identified in order to facilitate the proper implementation. The programme should include:

- Project team: project organisational charts and the involvement of different organisations.
- A thorough review of all the available documentation from previous and ongoing relevant studies, including an analysis of potential overlaps and/or duplication with other relevant projects.
- Data collection and analysis activities should be described and planned. The basic information should be collected in consultation with key persons in the community. The following information can be collected but other may be relevant.
    - Frequency and severity of past hazards
    - Vulnerable households and groups.
    - Spatial characteristics
    - Existing social groups
    - Indigenous early warning practices
    - Capacity of the community
- Identification of key stakeholders and structured consultations, including workshops. Minutes from this consultations and workshops should be included in the report.
- Capacity building activities and a training plan should be fully depicted in order to ensure the proper management and maintenance of the EWS.

Also, field visits should be made to selected communities at risk, district offices and selected locations for monitoring stations in order to better understand issues with sustainability and community engagement. The outcome for these visits should be included in this report too.

10.1.2 Work plan

A chart describing the different tasks within the implementation programme should be completed. The work plan should be very detailed, describing all the different sub-tasks to be completed for every task. Verification means of the accomplished tasks should be identified. Checklists should be developed to ensure that all the relevant issues have been addressed.

10.1.3 Risk matrix

Constraints, potential problems and associated solutions should be identified before the implementation. It is also a requirement that a risk management workshop is held with key stakeholders before finalising the report and work plan.

10.2 Risk Analysis

Risk assessment is a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. This risk knowledge can be produced from a systematic exploration of hazards and vulnerabilities at every level (global, regional, national and local). Although modern technology can develop geo-referenced maps and overlays for multiple hazards and vulnerability, the resulting risk knowledge is most insightful when produced directly with and by those individuals and communities who are considered to be at-risk. At the community level, risk knowledge is often produced through community risk assessments. As previously noted, it is suggested that the risk assessment is carried out within the full EWS with a significant input from the community.

The roles of all the different agencies and organisations should be clarified, and the responsibility for coordinating hazard identification, vulnerability and risk assessment should be assigned to one national organisation. Also, legislation or government policy mandating the preparation of hazard and vulnerability maps for all communities should be in place.

National standards for the systematic collection, sharing and assessment of hazard and vulnerability data developed should also be implemented, including strategies to actively engage communities in local hazard and vulnerability analyses. This should be reviewed and updated each year, including information on new or emerging vulnerabilities and hazards.

The characteristics of the different hazards (e.g. intensity, frequency and probability) will have to be analysed, especially through an evaluation of the existing historical data. One of the main outputs from this exercise will be the development of hazard maps identifying the geographical areas and communities that could be affected. Once this information is available, community vulnerability assessments should also be conducted, using both historical data sources and potential future hazard events considered and also considering some factors such as gender, disability, access to infrastructure, economic diversity and environmental sensitivities.

The risk should be determined, based on the interaction of hazards and vulnerabilities for each region or community. This information should be disseminate to the different communities in order to ensure that the risk information is comprehensive and includes historical and indigenous knowledge, and local information and national level data.

Finally, a GIS database should be established to store all disaster and risk information, making it available to the public.

It should be noted that this implementation stage has been completed to some extent by previous studies. However, as recommended throughout the document, there is further and more detailed work to be carried out for each of the hazards in the communities.

10.3 Monitoring - Data Acquisition

Within the different schemes several monitoring procedures have been described. In most of the monitoring components there is a requirement for the deployment of one or several equipment. The acquisition, deployment and management of these instruments should be undertaken with special care.

It is very important that the selected equipment for the systems comply with the initial requirements. A summary and purpose of the selected equipment can be found below.

10.3.1 Water Level Monitoring Sensors

The main purpose of the water level monitoring sensors is to corroborate the flood danger upstream of the community based schemes. Two different sensors should be acquired for the two different schemes.

10.3.2 Staff Gauges

Several staff gauges should be acquired for water level monitoring at the selected flood EWS communities. Six staff gauges (3 one meter staff gauges per community) have been defined.

10.3.3 Extensometers

The main purpose of the extensometer is to warn about any significant displacement in a landslide EWS. In this case two extensometers should be acquired. One to be deployed and one as a replacement.

10.3.4 Automatic Weather Stations

The automatic weather stations (AWS's) are probably one of the most significant equipment to be acquired for the EWS schemes. They fulfil many roles and their deployment is very important.

Within the flood EWS system the AWS's will provide precipitation information for the system. The raingauges within the AWS can be set up to send alarms when pre-defined thresholds are surpassed. Four stations will be required for the flood scheme, two in Aissirimou catchment and another two in Cassa catchment.

Within the landslide EWS system the AWS will provide information in both precipitation and on soil moisture. The former is vital for the operation of the system and the latter is considered as a future improvement. One station in Aituto is required.

Within the strong wind EWS system, the AWS's will provide wind speed, wind direction and gust speed information to the operational centre. Two stations in Ainaro will be required for this. The other two selected locations for the strong wind EWS (Aituto and Cassa) will make use of the stations deployed for the landslide and flood EWS's respectively.

All the stations should have telemetry capabilities and data should be sent periodically (at least every 3 hours but preferably every hour) to the NDMG.

10.3.5 Upgrade of Existing Stations

The upgrade of the existing stations should also be considered. There are numerous stations deployed in the study area with no telemetry functionality. The addition of this functionality does not entail a major cost and the addition of the data from these stations to the whole system would be highly beneficial.

The locations of some of monitoring equipment have been described in previous sections. It is important that further field investigations are carried out in order to select the most appropriate locations for all the sensors.

10.4 Data interpretation and procedures for issue of warnings

The main objective of this task is to develop the operational procedures and inter-agency collaboration required for operation of the early warning services. These requirements should include (but not be limited to) preparation and agreement of the items shown below. Identify key stakeholders, propose an initial list of requirements, collect and use feedback from those stakeholders at several meetings and/or workshops, and finalise the requirement based on comments received should be the main subtasks.

10.4.1 Service level agreements / Memoranda of Understanding

There are many elements within an early warning system. In this case, because several hazards are being considered, the system is likely to require inputs of expertise from a number of different organisational and professional cultures. Technical interests will be involved, as well as those from the social and behavioural sciences and the field of emergency management. Ensuring that these inputs mesh effectively and are each developed optimally will be one of the major challenges involved in the development of the system. Also, input from the communities will also be required.

The following items have been identified:

- Provision of weather forecasts and meteorological observations for use in the warning and forecasting. Possible sources for weather forecasts will be detailed below.
- Criteria/thresholds for issuing warnings: this is of special importance. Depending on the selected thresholds, warnings will be issued or not. The criteria for selecting these thresholds has to be thoroughly assessed. Historical and modelling data should be revised in order to obtain those thresholds.
- Provision of river level and precipitation observations to community-based schemes, and other groups, especially when thresholds are exceeded.
- A summary of the level of technical and other support which is available to NGOs and others to help to establish community-based flood warning schemes (e.g. design, provision of gauges, communications and emergency response exercises).
- Criteria for performing a post-event review following major incidents, and inputs expected from each organisation.
- Standards of service for the warning service

10.4.2 Work Instructions / Directives / Standard Operating Procedures

The different work instructions and standard operating procedures for the early warning system should be defined. A careful assessment of all the different procedures should be carried out, and this should include at least the following:

- Definition of rainfall depth-duration thresholds (for the landslide and flood schemes): in combination with other variables, as previously noted, thresholds for rainfall-depth should be defined. Antecedent conditions should be included in this definition of thresholds. A matrix with several combination of the above parameters could be set up in order to help on the definition of the thresholds.
- Definition of displacement thresholds (landslide EWS)
- Definition of wind thresholds (strong wind EWS)
- Management, validation and interpretation of monitoring data: this procedure should deal with the different aspects regarding data collected from the monitoring stations. Some of these procedures have already been defined in the work plan for the implementation of the monitoring network.

  The proper management of the collected data is of paramount for the success of the network itself and the EWS. Telecommunication protocols should be put in place and transmission reliability on a range of weather conditions should be tested. Data storage and database systems should be considered.

  A validation of the proper recording and measuring conditions of the deployed sensors should also be accomplished.

  Finally, the interpretation of the measures would be linked to the several threshold definition.
- Roles and responsibilities of key officers.
- Duties and accreditation of sensor observers and associated training requirements
- Performance monitoring and post-event reviews/reporting
- Organising and running an emergency response exercise
- Use and operation of emergency communications equipment including routine testing outside of the main hazard season
- Event data collection (extent, impacts etc.): An event information record may usefully be held on cards designed to a pro-forma for listing causes and effects. Good records give excellent general pictures and form a much better basis for developing warnings than simple desk studies.
- Analysis of the synoptical situation of past events

- Analysis of past “missed events”.
- Health and Safety in routine and disaster conditions
- Interpretation of data: To make sense of a disaster prediction, and to form a practical basis for communicating it, any prediction cast in terms of sensor or forecasting information must be translated into terms which describe the coming disaster likely consequences in the area which will experience the hazard. This means adding value to the prediction by giving it horizontal expression and meaning.
- Defining warning messages: Precisely what needs to be said in warning people, and how the messages should be couched, constitute key procedures. Some messages that are disseminated can be too bureaucratic and fail to create the necessary bridge between the appraisal of disaster characteristics (prediction and interpretation) on the one hand and the making of decisions about protective behaviour on the other. Messages can all too easily be neither user-friendly nor persuasive and can fail to incorporate all the appropriate information. Therefore, warning messages would need to describe the coming disaster, say what it will mean to those who may be affected by it and indicate what actions they should take. Simple but evocative language should be used, with an emphasis on the creation of word pictures designed to create arousal and overcome apathy and denial. The ‘community memory’ should be tapped, where possible, by referring to known disaster of the past and referencing the likely severity of the coming event to them. Warning messages should not be ‘singular’ in the sense that one message is provided for a whole community, because it would fail to recognise that the community is not a single mass of people but is stratified in terms of degree and type of risk, past experience, language and other differentiating characteristics. Different groups will need different information presented differently, so a matching of message and group will be necessary.

10.4.3 Warning Procedures / Concept of Operations / Response Plans

The following procedures regarding warning, operations and response plans should be defined:

- Warning procedures defining roles and responsibilities
- The criteria for opening the operations room/moving to 24/7 operation
- The criteria for staff reinforcements during peak hazard season
- Establishing a duty roster
- The thresholds for issuing warnings,
- Instructions for disseminating warnings and interagency communications (phone/radio conferences etc.),

- Record keeping requirements (incident and communication logs, situation reports etc.)
- Handover arrangements between shifts
- Temporary secondment of experts between operations centres during events and longer term

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10.5 Planning for the Dissemination of warnings to districts and communities

This task is specially aimed at the development of effective and reliable techniques for disseminating warning information to the relevant parties. These procedures will be key in determining the data flow requirements for both warnings and ongoing dissemination of information during and after events.

In order to design this task properly, the data flow within the dissemination component needs to be developed in further detail. This is especially important to ensure that ICT infrastructure and other resources are correctly specified to meet the institutional and procedural requirements.

The existing dissemination component within the current disaster warning in Timor Leste is undertaken mainly by NDOC. Dissemination and response protocols are very detailed in the NDOC Standard Operating Procedures Document (see Deliverable 2).

The best approach in the designing process of the dissemination component would be to maximise utilisation of existing available ICT tools in alerting communities of impending disasters, in coordinating response and rescue, and in managing mitigation programmes and projects. The existing available ICT tools, however, seem to be insufficient in this case. The development of a web-based platform to share data, especially during events, should be considered with detail. Also, the use of mobile telephone communication to notify the communities appears also to be insufficient. While this communication method may be reasonable for the more common and lesser events, severe disasters with complex and widespread impacts are likely to require a more variegated approach involving both specifically targeted warning messages and the use of a range of dissemination channels which may include remotely-activate sirens, loudspeakers, computer transmissions, door-knocking and even, for long-response events, newspapers. The choice of modes will be dictated by onset time, likely severity and nature of community but, in general, the principle of using methods in layers should be observed since different people hear and respond to differing degrees to various means of receiving information. Using a range of disseminating messages also helps to satisfy the need for confirmation. The provision of a telephone number and webpage which people can call or visit for clarification, repetition or other assistance is also recommended. Subscription services should also be considered. These services will help in addressing the message to the relevant stakeholders when necessary and different types of messages can be configured for different recipients. Also, where evacuation is likely to be necessary, it would be recommended to set up a system attempting to personalise message delivery by individually door-knocking those buildings from which people will have to move. This will ensure that the safety requirement is optimally discharged since personally-received warnings are more likely to be understood and believed and therefore acted upon than those received by more remote.

The design of this dissemination component needs to detail the requirements for data exchange prior, during and post events. These requirements should be developed in conjunction with the other tasks and especially in consultation with the key stakeholders involved in dissemination of warnings and ongoing management of events both nationally and at regional and community scheme level. This requirements should include:

- estimates of maximum number of voice calls required at critical times
- estimate of maximum internet bandwidth required at critical times
- requirements for timing of escalations in event of non-response to warnings
- analysis of all necessary data paths

The current communications ICT infrastructure currently available should also be analysed in detailed during the implementation period. This analysis should include an assessment of:

- capacity
- reliability (with particular reference to emergency conditions)
- cost
- usability

The outcome of the above requirements analysis and current equipment assessment will provide the basis for determination of new equipment requirements.

10.6 Establishment of Specific Community warning schemes

Key activities within this task shall include:

- Consultations with district and community leaders on establishing schemes (zones) and hazard issues, including walkover site visits
- Identifying vulnerable groups and particular assistance needed during disasters (elderly, disabled, children, seasonal workers, schools, fishing communities etc.)
- Using a GIS-based approach, develop warning and evacuation maps showing evacuation routes, shelters, the locations of vulnerable people/groups, critical infrastructure, NGO offices, health facilities, and other operationally useful information, with hazard impact extents, and if possible linked to sensor information
- Appointing and training volunteers and establishing duty rosters, including volunteer 'spotters' not directly involved in the warning process
- Developing warning thresholds appropriate to each community (or group of communities)
- Ensuring that centrally (telemetered) observations and forecasts are available at district and community level (e.g. via mobile phone calls, SMS and/or a website) and that training is provided on how to interpret the information
- Developing a community-specific engagement programme (e.g. meetings, plays, leaflets, posters, school classwork)
- Developing a plan to enhance dissemination activities within the community
- Developing a plan to enhance response activities within the community

10.7 Development of Forecasting Capability at National Level

Several forecasting procedures have been described for the flood, landslide, strong winds and fire hazards. The complexity of the forecasting varies. The implementation of the following forecasting systems is necessary. Details of these forecasting systems have been given throughout this document.

10.7.1 Flood Forecasting

A very basic flood forecasting platform has been defined. The use of NWP models for precipitation forecasts have been defined. The precipitation forecasting information is available from different sources such as:

- The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) NWP model
- The Australian Bureau of Meteorology NWP model
- The Indonesian Meteorological Department NWP model
- The North America Oceanographic and Atmospheric Administration (NOAA) GFS NWP model

Some of these models are open-source while special agreements for other models exist. It is advisable that the output accuracy, horizontal resolution, forecasting time-frame and reliability from all these different models is analysed. Also, it would be advisable that at least two models are selected, in case one of them fails to deliver data.

Procedures from operationally acquiring and processing data should be implemented.

10.7.2 Landslide Forecasting

The landslide forecasting system will initially make use of the same precipitation data as the flood forecasting model. Different procedures should be established in order to define the different thresholds for landslide triggering.

10.7.3 Strong Wind Forecasting

The initial choice of models for the strong winds forecasting is the same as per the two previous hazards. However, the final choice of models for this hazard would depend on the required analysis regarding the accuracy and suitability of these models specifically for the strong wind hazard.

10.7.4 Fire Forecasting

The forecasting models to be used within the fire EWS have already been described within the fire EWS.

11 Maintenance

Several maintenance activities are described in order to ensure the sustainability of the system.

11.1 Equipment

One of the key tasks within the maintenance component is the equipment maintenance. This has been identified as a very risk issue in Timor Leste. It is very important that personnel within relevant organisations are fully prepared to maintain the equipment and system implemented within these schemes. In the case that this preparedness does not exist, this should be identified and associated training should be undertaken.

This training should also be undertaken at community scale in order to ensure that the implemented system at this level are also properly maintained.

11.2 Training

Routine training activities should be organised, both at local (community) and state level (full system). The staff working on the operation of the system should keep up-to-date on current system developments worldwide and should participate in several training sessions to work on the constant improvement of the system.

From a community point of view, training sessions help to keep community members aware of the existence of the system and of its constant development.

11.3 Post-event evaluation

Post-event surveys should be carried-out after every event for the analysis and improvement of the EWS. Checking out the extent of damage and the timing of the arrival of the event is one reason of undertaking a post-event investigation and analysis.
Regarding community involvement, a session with all of the key players in the EWS should be organised after every event in order to identify the problems encountered, the weak and strong points of the system and ways to improve it.

There are some key questions that should be addressed after every event:

- How did the existing EWS perform? The four components of the EWS should be analysed and flaws detected and improved.

- In particular, how did the existing forecasting platform perform?
- What was the dynamics during the event? The influence of the different factors should be analysed. For instance, regarding a flood event, the rainfall-runoff dynamics, the watershed characteristics, the initial soil moisture or ground water recharge conditions and pre-existing water levels should be analysed if possible.
- What part of the catastrophe can be attributed to anthropogenic factors? Such as change in land use, deforestation, new agricultural drainage or road network.

11.4 Review

The design of warning systems needs to be regarded as a continuous process of construction and review which will have periods of intense activity (especially during and immediately after events) and periods of less intense but highly important planning work. All components (risk knowledge, monitoring and prediction, dissemination and response) need to be reviewed in a debriefing context for weaknesses of detail and design, and deficiencies should be rectified in the ongoing planning phase. In all of this, contact needs to be consciously sought with members of communities at risk. While system modification is especially likely a post-event evaluation as detailed above, it will also be appropriate when significant altering environmental changes occur, when relevant technological innovations become available, or when additional resources are obtained.

In the study area in particular, some events may be infrequent. To counter the accompanying negative consequences as far as system readiness is concerned, reviews need to be held occasionally even if there have been no significant event and no significant environmental or technological changes to consider. These may take the form of workshops designed to bring together the various interests involved in system development and warning service delivery so that the potential participants can see their own roles in the context or those of other players and so that new players can be introduced to the process.

Equally, workshops may take the form of test exercises (drills, please see below) in which new or alternative methods can be evaluated. In all of this it is important to involve the relevant communities. There is a sense in which people need to be prepared for warnings as well as to be warned about impending events, and this requires a willingness to develop public awareness initiatives out of event time. Plans describing operating warning systems and procedures can be made available in public libraries and advertised or exhibited in local media outlets, and awareness material can be distributed to households and businesses in particularly prone locations.

11.5 Community drills

A community drill plan should also be implemented. Drills should be organised on a regular basis, at least once per year, to determine community actions and response times and to identify possible problematic areas.

12 Future Improvements

The system described above meets the very basic requirements for a multi-hazard EWS at community-based scale. Some suggestions and recommendations at National have been detailed, especially in order to support community possibilities and capacities. There are some recommendations for future improvements. It is not expected that these improvements are implemented at this stage. However, the following future improvements described below would significantly improve the existing and the proposed EWS.

13.1 Meteorological Forecasting

There is no national numerical weather prediction (NWP) model for Timor-Leste. The implementation of a NWP model requires certain capabilities, both from a technical and from an operational point of view. The maintenance of an operational forecasting system is significantly demanding.

A local model will allow to customise the resolutions and outputs to the actual requirements of the EWS. Precipitation, wind and humidity forecasting data are some of the outputs a NWP model can provide operationally. There are several numerical models available that could be used, such as WRF, MM5, Aladdin or Hirlam.

It should be noted that the meteorological forecasting system does provide input data for the flood, landslide, strong wind and fire systems, and therefore this is considered to be the most critical suggested future improvement.

13.2 Provision of Data for Assimilation Purposes

Numerical Weather Prediction (NWP) Models can benefit considerably using assimilation data. Assimilation procedures are very complicated, and not all the meteorological operational models use them. However, it is widely accepted that the forecasting results using assimilation data are considerably better. This is especially the case for both wind intensity and temperature. Therefore, it is suggested that in the near future that the National Directorate for Meteorology and Geophysics (NDMG) starts providing these data (in WMO format) to relevant organisations, especially the Bureau of Meteorology of Australia and the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia.

13.3 Precipitation Data from Satellites

Precipitation data from satellites is a good source of rainfall data, especially in areas where no precipitation radar is available. There are different options for this type of data but two different sources of satellite derived-precipitation are available.

Multi-sensor Precipitation Estimate (MPE)

Multi-sensor Precipitation Estimate (MPE) is an instantaneous rain rate product, which is derived from a combination of passive microwave imager measurements from low orbiting satellites and infrared data from geostationary satellites. Data from low orbiting satellites shows low spatial and temporal resolution with acceptable accuracy, whereas IR data from geostationary satellites yields high spatial and temporal resolution but lower accuracy data retrieval. Processing is done in near-real time mode with a time delay of less than 10 minutes between image acquisition and data dissemination. Data are provided on the internet in GRIB-2 data format. Data is available every 15 minutes in a 4 kilometres grid.

TRMM / GPM

The 'Tropical Rainfall Measuring Mission (TRMM)' a joint space mission between NASA and the Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rainfall. This mission has been providing rainfall estimates from 1997, and it should be noted that this rainfall estimates has actually been used to calibrate most of the satellite rainfall estimates algorithms used today. The TRMM mission will be terminated around February 2016. However, a similar mission (Global Precipitation Measurement (GPM)) by both NASA and JAXA too, and with a very similar configuration was launched in February 2014.

TRMM and GPM data are available through different means. Historic TRMM data is available in ASCII and netCDF format. GPM real-time data is available in HDF format through several FTP´s.

13.4 Hydrological Forecasting

The implementation of a hydrological model is highly recommended. A hydrological model will provide the response of a catchment to certain meteorological conditions. The output from a hydrological model is mainly discharge information and soil moisture. This information can be used in conjunction with a hydraulic model, but also can be used as a single tool to issue warnings.

The implementation of a hydrological model requires certain technical capacities. Some of the hydrological models available are HEC-HMS, MIKE NAM, TOPKAPI, LISFLOOD or CREST.

13.5 Hydraulic Forecasting

The implementation of a hydraulic forecasting model would be the next logical step after the implementation of a hydrological forecasting model. The complexity of a hydraulic model is a bit higher than of a hydrological one. Even if a hydrological model could provide discharge and warning information by itself, the coupling of these two models is recommended in order to increase the accuracy of predictions. A hydraulic model routes discharge information from the hydrological model using topographic and structural information, providing water level and discharge data along the whole model domain. This effectively leads to flood mapping when combined with elevation data.

Some of the most widely used hydraulic models for operational purposes are MIKE 11, HEC-RAS, InfoWorks, SOBEK or ANUGA.

13.6 Formal Flood Forecasting System

The implementation of a full formal flood forecasting system is recommended for the main catchments in the study area or in the whole Timor-Leste. A formal flood forecasting system would be using information from three of the improvements described above.

A basic flood forecasting system should have the following three main components:

1. Input component: remote sensing data, global forecasting data and information from the monitoring network will be controlled by this component.
2. Modelling component: the main forecasting local activities will be carried out within this component. A hydrological and flood inundation modelling framework should be developed. The implementation of a weather forecasting model should also be considered.
3. Output component: information from the two previous components will be utilised in order to determine if flood warnings should be issued depending on thresholds, existing conditions and local information.

13.7 Landslide Forecasting

The implementation of a more sophisticated landslide forecasting system is recommended. In this case for future steps and improvements. The use of a combination of rainfall duration, intensity, soil moisture and forecasting information in combination with a meteorological and hydrological model is recommended. Also, a better description of different type of soils is advised. Information from the existing system should be used, in a lesson learnt exercise, in order to improve the existing system too.

13.8 Improvement of Landslide Monitoring

As previously noted, the community-based landslide monitoring network described above meets the initial requirements for the EWS, but the network can be extended to improve monitoring and warning capabilities. Tiltmeters, cameras and automatic extensometers are recommended for further stages of the EWS.

13.9 Fire Danger Forecasting

As previously noted, it is recommended that at this stage the monitoring and warning component for the fire hazard it is based Global Early Warning System for Wildland and the Malaysian/Indonesian Fire Danger Rating System (FDRS) for Southeast Asia. This system does provide information at a broad scale, and a finer resolution would be recommended.

The implementation of the Canadian Forest Fire Weather Index is recommended. This system is the most widely used system and it is not extremely data demanding. Basically, all the required data for its implementation can be obtained from open-source satellite data. It should be noted that the implementation of such a system is very demanding. International cooperation can be sought for this implementation. For example, the system implemented in Malaysia and Indonesia for the Fire Danger Rating System for Southeast Asia was undertaken in close cooperation with Canadian Cooperation and Forest Service Agencies.