CHAPTER 3. BASIC ANALYSIS

3.1 Geo-morphological Analysis

3.1.1 Preparation of Geo-morphological Land Classification Maps

(1) Objective and Method of Preparation

Geo-morphological land classification maps were made for the objective six river basins as a first step for the preparation of flood and sediment hazard maps. Landforms are interpreted using aerial photographs newly taken in this Study, and the results were transferred to 1/50,000 or 1/100,000 topographical map sheets. Fig.3.1.1 is a sample for the Ourika River, and those for the other five river basins are presented in Volume 3, Supporting Report Appendix B: River Morphology.

(2) Landform Classifications in Geo-morphological Land Classification Map

The landform interpretation was based on the landform classifications given in Table 3.1.1, each of which are generally related to potential disasters as follows:

Relationship between Land Classification and Potential Disasters

Landform classifications	Flood	Sediment Flow	Debris Flow	Slope Failure	Large-scale Slope Failure	Land Slide	Rock-fall
Steep Slope				H	L		H
Riverbed	H	H	H				
Floodplain (valley plain)	H	H					
Alluvial fan	H	H					
Former waterway	H	H					
Natural levee	H	H					
Flood-prone terrace	H	H					
Terrace							
Shallow Valley	H						
Terrace cliff				H		H	H
Alluvial cone (debris flow-prone alluvial fan)	H	H	H				
Talus				H			H
Pediment		H	H	H			
Landslide morphology (creeping slope)				H	H	H	H
Landslide scar					H	H	H
Erosion Surface		L					
Moraine				H			H
Cirque				H	L		H

H: Potential is high, L: Potential is low, Blanc: Potential is nil.

3.1.2 Preparation of Disaster Hazard Map

Following the geo-morphological maps, disaster hazard maps were also prepared for the six river basins to identify areas vulnerable to disasters such as debris flow, slope failure and land slide and flood inundation. Fig 3.1.2 is a sample of the Disaster Hazard Map for the Ourika River Basin. Those for the other basins are presented in Volume 3, Supporting Report Appendix B: River Morphology.

Damage potentials are generally functions of magnitude and occurrence probability of the natural phenomena and distribution of assets to be protected. For the hazard maps, houses and buildings, and roads were considered as important assets to be protected from the disasters, as follows:

- Houses and buildings (including those in Azib)
- Major roads (the roads along the Ourika and Rheraya valleys, the national road leading to Ouarzazate and Taroudannt, and the road from the Ourika valley to Oukaimedan)

(1) Potential Debris Flow Disaster Stream

Generally the larger the slope of stream bed and the larger the catchment area, the greater the danger of debris flows. Risk of debris flows is then assessed based on combinations of the stream slope and the catchment area upstream of a point where a debris flow was likely to occur (where the stream slope is 15 or higher degrees). This method of risk assessment using the stream slope and catchment area is based on a Japanese guideline for investigating torrential mountain streams and debris flow-prone areas. In Japan, geomorphology, geology and vegetation cover in the basin are also considered in risk assessment.

A total of 1,431 streams were identified as potential debris flow disaster streams through close examinations based on aerial photographs and topographical maps. Among them 960 streams are ranked A, the highest in terms of disaster risk. The number of the potential disaster streams by river basin is given as follows:

Number of Potential Debris Flow Disaster Streams

River Basin	Catchment Area (km^2)	Number of Potential Streams
R'dat	1,256	285 (170)
Zat	221	147 (91)
Ourika	495	330 (267)
Rheraya	528	145 (111)
N'fis	532	488 (304)
Issyl	421	36 (17)
Total	3,453	1,431 (960)

Numbers in parentheses are the numbers of those of Rank-A.

(2) Potential Slope Failures Disaster Areas

The failure of surface layer due to heavy rain is likely to occur on slopes with a gradient of 30 degrees or more. Most parts of the Study Area are located in steep mountain areas. The mountainside slopes except flat or mild slopes at the summits, terraces, alluvial fans and floodplains are mostly sloped at 30 degrees or more. These slopes are, therefore, vulnerable to failure. It is said that debris travels a distance two to three times longer than the height of the slope. After the preparation of geo-morphological land classification maps, therefore, slopes of 30 degrees or more including the assets to be protected within the travel distance were extracted as Potential Slope Failure Disaster Areas .

A total road length of 164 km was found under a threat of such slope failures. The number of the potential disaster areas by river basin is given as follows:

Number of Potential Slope Failure Disaster Areas

River Basin	Catchment Area (km^2)	Number of Potential Slope Failure Disaster Areas	Road Length under threat of Slope Failures (km)
R'dat	1,256	225	37
Zat	221	180	5
Ourika	495	240	36
Rheraya	528	128	14
N'fis	532	490	69
Issyl	421	17	2
Total	3,453	1,280	164

(3) Potential Landslide Disaster Areas

Of areas classified as the landslide morphology (creeping slopes) in the geo-morphological land classification maps, those with the assets to be protected were specified as Potential Landslide Disaster Areas.

A total of 226 areas are identified as Potential Landslide Disaster Areas. A total road length of 18 km was found under a threat of landslides. The number of the potential disaster areas by river basin is given as follows:

Number of Potential Landslide Disaster Areas

River Basin	Catchment Area (km^2)	Number of Potential Landslide Disaster Areas	Road Length under threat of Landslides (km)
R'dat	1,256	61	5
Zat	221	70	0
Ourika	495	23	9
Rheraya	528	35	2
N'fis	532	30	2
Issyl	421	7	0
Total	3,453	226	18

(4) Flood Inundation Area

After the preparation of geo-morphological land classification maps, areas vulnerable to inundation by flood were determined based on the geo-morphological land classification maps and the hydraulic simulation (refer to Section 3.2).

Present river beds with a gradient of 3 degrees or less, flood plains, lower terraces, alluvial fans, former waterways, natural levees are included in the flood inundation areas. As for the Issyl River Basin of which the downstream areas are mostly classified as alluvial fans, inundation of the main stream and major tributaries was taken into consideration, but inundation from the Rheraya River was not considered although it possibly affects the left bank of the Issyl River.

3.2 Hydrological and Hydraulic Analysis

3.2.1 Availability of Hydrological Data

(1) Rainfall

Four agencies, ABHT, DMN, MCEF, and MOI mainly observe rainfall in and around the Study Area. Besides, some rainfall gauging stations are operated by the other agencies such as ORMVHA. Their locations are shown in Fig. 2.8.1.

Among the total 48 rainfall gauging stations in and around the Study Area, representative 29 stations have been selected as shown in Fig. 3.2.1 for the following hydrological analysis, considering data availability and spatial distribution of the stations. The stations are listed in Table 3.2.1.

An automatic rain recorder has been installed at the Aghbalau Station (ABHT) and the Oukaimeden Station (DMN) in the Ourika River Basin, and the Marrakech Stations (ABHT and DMN) beside the Issyl River Basin. Among these automatic gauging stations, the Aghbalau (ABHT) Stations have continuous records over some 20 years, while records of the other stations are not continuous and of shorter observation period.

(2) Water Level and Discharge

Water level is measured by ABHT in the Study Area at the stations presented in Fig. 3.2.1 and Table 3.2.2. Among these stations, the Sidi Rahal, Taferiat, Aghbalau, Tahanaout, Imin el Hammam, and Iguir N'kouris Stations are principal stations. In these principal stations, discharge measurement is made once a month for making rating curves for conversion from water level to discharge.

The other stations are simple stations that were newly installed for the flood watch purpose after the 1995 disaster. At these simple stations discharge measurement is rarely made but river cross section survey is made once a year.

3.2.2 Characteristics of Rainfall and discharge

(1) Altitude and Rainfall

The Study Area extends in altitude from 500m at Marrakech to 4,167m at Mt. Toubkal, while the locations of the rainfall stations are biased to lower areas with the Amenzal Station at 2,230m as the highest station. In this connection, the relationship between altitude and rainfall is examined to estimate rainfalls at high altitudes.

Fig. 3.2.2 shows that relationship between altitude and annual rainfall. A clear trend can been seen. The higher the altitude is, the more it rains. This relationship will be very useful to analyze the spatial variation of rainfall and to draw an isohyetal map as shown in Fig 3.2.3. The annual rainfall depth in the Study Area increases from north to south, ranging from 250 mm in Marrakech to 700 mm in the High Atlas Region.

(2) Seasonal Rainfall

A year is divided into three seasons in terms of rainfall patterns: dry summer and two rainy seasons (winter and spring). Summer can be defined as four months from June to September, winter from October to January, and spring from February to May respectively, as defined by *"Amenagements Hydrauliques pour la Protection de la Vallee de l'Ourika Contre les Crues, Mission I, Mars 1996 INGEMA"*.

Fig. 3.2.4 indicates the seasonal variation of rainfall by basin. Except the N'fis River Basin, the seasonal depth of rainfall is recorded higher in spring than in other seasons. In the upper N'fis River Basin including the Arhbar, Talal Nous, Idni, Ijoukak and Iguir N'kouris Stations, rainfall is more in winter. On the other hand, spring rainfall is dominant with an amount of over 200mm in the Rheraya, Ourika and the R'dat River Basins.

During spring, the maximum seasonal amount of rainfall is recorded in the Toufliht Station (the R'dat River Basin) with an average of 411mm, followed by those of the Agaiouar and Aghbalou Station (the Ourika River Basin) with 311 and 310 mm, respectively. In winter, it is the Arhbar Station on the upstream of the N'fis River that comes first with a total of 344 mm, followed by the neighboring Idni Station with 286mm. Summer is a dry season in general, and the seasonal average amount of rainfall depth never exceeds ten millimeters in all the basins. Summer is a season of local and short duration storms, and not of long-lasting and sustained rainfall. Finally, it is noted that maximum amount of rainfall in summer is recorded in the Agaiouar Station with an average of 61.3mm, followed by that of the Toufliht Station with 52.4mm. The minimum was recorded in the Lalla Takerkoust and the Marrakech Station with 19.2 and 20.8mm respectively.

(3) Intensity-Duration-Frequency Relationship

Rainfall intensity is one of the most important factors of such a flash flood in the Study Area. An insensitive rain causes a flash flood in a short time. It rapidly saturates the soil, and generates surface torrents that erode the riverbank.

Based on the collected rainfall data at the Aghbalau Station, an intensity-duration-frequency analysis has been carried out for different duration of 15, 30, 60, 120, 180, 360, 720, and 1440 minutes. The results are presented in Table 3.2.3 and summarized as follows:

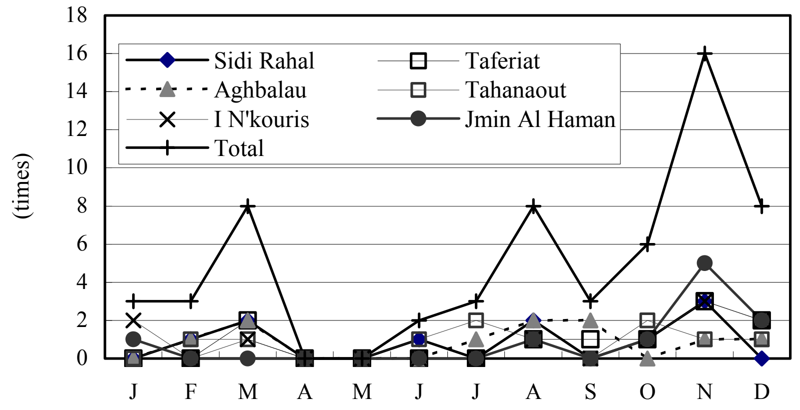
Intensity-Duration-Frequency Relationship at Aghbalau

(mm)

Return Period	Duration of Rainfall							
	15 min.	30 min.	60 min.	120 min.	180 min.	360 min.	720 min.	1440 min.
2 years	6.1	9.6	15.6	23.4	26.1	32.9	37.1	47.7
5 years	7.5	13.1	27.1	36.5	38.5	44.7	47.8	61.5
10 years	8.2	14.6	32.2	42.5	44.1	50.0	52.6	67.8
30 years	10.0	18.7	46.0	58.3	59.1	64.2	65.5	84.5
50 years	10.6	20.3	51.2	64.3	64.7	69.6	70.3	90.9
100 years	11.6	22.4	58.3	72.0	72.4	76.5	76.9	99.4

(4) Flood Season

In the Study Area, the winter season has the highest frequency of floods followed by summer and spring. The 10 largest floods at each principal station are given in Table 3.2.4 and the frequency is shown in the figure below.



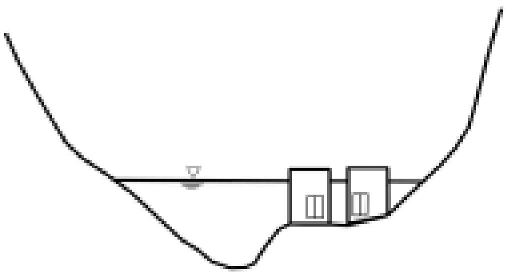
Frequency of 10 Largest Floods by Month

3.2.3 Establishment of Flood Simulation Model

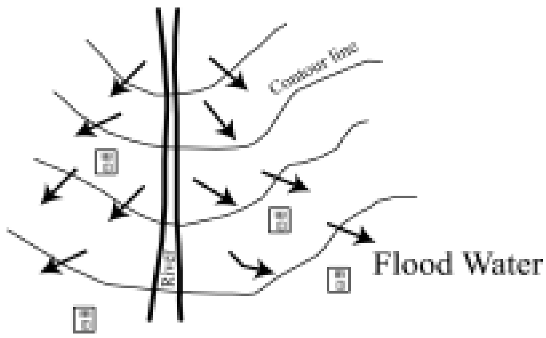
To identify probable flood inundation area along the N'fis, Rheraya, Ourika, R'dat, Zat and Issyl river basins, and to determine basic hydrological parameters for flood forecasting modeling, a flood simulation model is established for the objective six rivers.

(1) Selection of Software

Since the five rivers other than the Issyl all flow down in valley areas, flood water is confined in the rivers and the river banks. The Issyl River flows down in the alluvial fan area, in which floodwater spreads over.



Flood Inundation in a Valley
(5 rivers except Issyl River)



Flood Inundation in an Alluvial Fan
(Issyl River)

s
selection of software for establishing a simulation model for these rivers shall be made in consideration of the above characteristics. The following software is selected for the six objective rivers.

Selected Software for inundation analysis

River	Type of Inundation	Proposed Software
5 Rivers other than Issyl River	Confined in valley	ISIS* (one-dimensional dynamic flow model)
Issyl River	Diffusive over fan	Two-dimensional dynamic flow model

(a) ISIS

ISIS is a package software supplied by HR Wallingfort. ISIS software is suitable for a wide range of river engineering and environmental applications, from calculating simple backwater profiles to modeling entire catchments. The ISIS software is a modular software system for simulating flow, hydrology, water quality and sediment transport in canals, rivers, flood plains, estuaries and catchments. The core of software is summarized below.

ISIS Software Package

Available Module	Contents of Module	Use in this Study
ISIS Flow	Hydrodynamic modeling of open and converted channel system.	Yes
ISIS Steady	Backwater computation, including trans-critical flows	Yes
ISIS Routing	Flood Rooting	Yes
ISIS Hydrology	Rainfall-runoff modeling	Yes
ISIS Quality	Water quality process modeling	No
ISIS Sediment	Sediment tranceport modeling	No
ISIS WMS	Mapping module (Flood inundation area)	Yes

(b) Two-dimensional dynamic flow model

For the Issyl River, a two-dimensional dynamic flow model is applied. This model divides the flood plain into many square cells, every of which is given hydraulic attributes such as elevation and roughness. The dynamic flow equation is solved two-dimensionally. The ISIS hydrological module can be used for estimation of the boundary conditions.

(2) Elaboration of Flood Inundation Simulation Model for Ourika

First a flood simulation model has been elaborated for the Ourika River of which hydrological data accumulation is not sufficient but better than any other river basins. The following is a description of the elaboration of the simulation model for the Ourika River.

(a) Model Structure

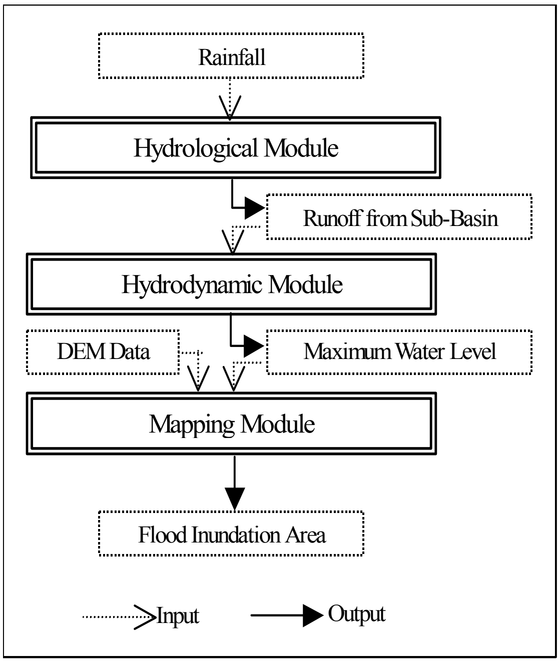
The hydrological module (rainfall-runoff module) based on the USSCS method calculates runoff generated in the sub-basins. The calculated runoff from the sub-basins is given to the dynamic flow module as the upstream end model boundary or lateral inflows from tributaries.

For the flood routing in the river channel, the hydrodynamic module is used. The hydrodynamic module is a one-dimensional dynamic flow model for which the Saint Venant Equation is applied. Hydraulic parameters such as water levels, velocities and discharges can be estimated at any points of the channels.

The calculated water levels are transferred to the WMS module for preparation of a flood map. The WMS module is a mapping module to define flood inundation areas and depths by comparing the river water levels with the ground elevations.

(i) Runoff from Sub-basin

The USSCS method that is one of the runoff analysis models included in the hydrological module of ISIS has been applied for runoff analysis for the sub-basins. This USSCS model is a kind of the unit hydrograph method that was developed by the United States Soil Conservation Service.



The Ourika River Basin is divided into six sub-basins, considering locations of major tributaries and topographical conditions. Fig. 3.2.5 shows the topology, vegetation and lithology in the Ourika River Basin. The sub-basin boundary and a schematic diagram of the simulation model of the Ourika River Basin are shown in Figs. 3.2.6 and 3.2.7.

To determine a unit hydrograph for every sub-basin, the USSCS method is associated with the basin soil coefficient indexing CN value, concentration time, lag time and catchment area.

(ii) Flood Routing

The flood routing is made along the 25km stretch from Setti Fadma to Tnine Bridge (about 8km downstream of the Aghbalau Station). 50 cross sections with an interval of 500m that were newly surveyed in this Study have been used for the hydraulic simulation.

(b) Model Calibration

(i) Target Flood

The flood on 28 October 1999 for which the most hydrological records are available among the past major floods, has been used for the target flood of the model calibration. In a strict sense, hydrological data, especially rainfall intensity data are still insufficient for the model calibration. However, through a close examination of the model parameters and rainfall distribution in space and time, the reproduction of the 1999 flood has been attained as discussed below:

(ii) Calibration Result

Quite a few trial runs were made until an acceptable accuracy was obtained, adjusting the model parameters and rainfall distribution. The table below presents the final USSCS such parameters obtained through the calibration.

Parameters for USSCS Method

No of Sub basin	Catchment Area (km^2)	CN*1			Concentration Time*2 (hour)	Lag time (hour)
		CN I	CN II	CN III		
1	154.1	46	66	83	2.16	1.29
2	69.2	46	66	83	1.05	0.63
3	42.9	40	60	78	0.33	0.20
4	98.4	40	60	78	0.85	0.51
5	25.6	35	58	77	1.06	0.64
6	104.8	46	66	83	1.90	1.14

*CN Value decided by standard USSCS table.
*Concentration time is estimated by the Kirpich method.

Manning's roughness coefficients for the river stretch has been also determined between 0.045 and 0.055, so that the calculated river water levels could coincide with the observed maximum water level at the Aghbalau and Tazzitount Stations.

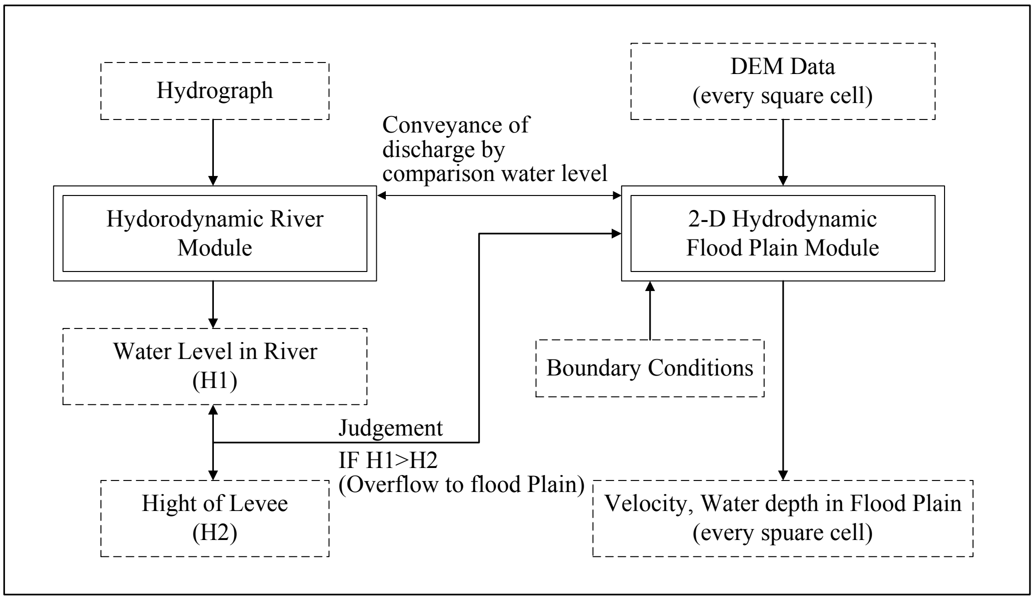
The simulated discharge hydrographs at the Aghbalau, and Tiourdiou Stations are presented in Fig. 3.2.8. The reproduction result is generally good enough, although some gaps between the estimated and observed ones are seen in the recession stage of the Aghbalau and in the rising stage of the Tiourdiou. In conclusion, the simulation model is acceptable and applicable for the Ourika River. Flood map in 1999 flood is shown in the Supporting Report.

(3) Elaboration of Flood Inundation Simulation Model for Issyl

Compared with the other basins, hydrological data accumulation in the Issyl River basin is so insufficient that no discharge observation station has been installed. Thus, the boundary condition is hypothetically presumed taking the past study in this basin into account. The following description explains the simulation model for the Issyl River basin.

(a) Model Structure

The model is mainly divided into two parts. One part is the Hydrodynamic River Module which is a one-dimensional dynamic flow model for calculating water level in the river. The other part is the Hydrodynamic Flood Plain Module which is two-dimensional dynamic flow model. The flood plain module starts to calculate hydraulic parameters such as water level, velocity, and in-out discharge every square cell after the river water level gets over the height of levee. These two modules are linked together with conveyance of in-out discharge between the river and flood plain by comparison of the water level.



(i) Flood Routing inside River Channel

The flood routing in the Issyl River was carried out along the 40km stretch from the Rocado channel to the downstream of Memorial Bridge. Forty (40) cross sections with intervals of 500m as surveyed in this Study were used for the hydraulic simulation of the Issyl River.

Hydrograph derived from the model Hydrograph (refer to the report entitled "ETUDE DE GESTION DES RETENUES ET DE PRODUCTION DES BERGES MISSION I") is presented at the upper edge of the river model.

(ii) Two-Dimensional Dynamic Flow for Flood Plain

The schematic diagram of the simulation model of the Issyl River basin is shown in Fig. 3.2.9. In this model, the flood plain is divided into 3,621 square cells with sides of 250m. Roughness coefficient, ground height, small channel, and banking are given into the cells.

(iii) Afflux at the Bridges

There are bridges remarkably disturbing the flow of the Issyl River. In this analysis, the afflux at the bridge was calculated using the method developed by Hydraulics Research, Wallingford. This method for arched bridges has been developed from laboratory tests on model bridges and verified with data from prototype bridges in the UK.

(b) Simulation Result

In a strict sense, hydrological data accumulation is insufficient for the model calibration. In this basin, discharge and rainfall intensity has not been observed. Only the peak discharge of $90m^3/s$ calculated by simple method at the Marrakech in the 1997 flood is known. Therefore, the simulation is carried out with the model hydrograph given the peak discharge of $90m^3/s$ on trial. The simulation result is shown in Fig. 3.2.10. In this simulation, the roughness coefficient for each cell is compounded for each land use, namely, Agricultural area (0.060), Road (0.047), and Others (0.050). Manning's roughness coefficient of the river channel is 0.040.

(4) Elaboration of Flood Inundation Simulation Model for Other Rivers

It is difficult to construct a hydrodynamic model without the many gaps between calculation result and actual data because rainfall intensity has not been observed at the N'fis, Wirgane, Rheraya, Zat and R'dat river basins. For these 5 rivers the model was made of the ISIS Flow module. This module carried out non-uniform flow calculation with distribution of discharge (without time series data) and calculated the water level at any point. Manning's roughness coefficient had the same value (0.045-0.055) as the Ourika River.

3.2.4 Preparation of Flood Map

Flood Map was prepared for every discharge probability in this study. For the flood map at the six river basins (except Issyl), the result of non-uniform flow was used because hydrological data has been stocked insufficiently for use of the hydrodynamic method that need the time series data by discharge probability. It is better to use the non-uniform flow rather than the hydrodynamics method including the many gaps generated when many prerequisite conditions are assumed. For the Issyl River basin, the two-dimensional dynamic method could be used with the information on the boundary conditions such as hydrograph pattern ABHT decided.

(1) Target Area of Flood Inundation Analysis

The target area was chosen with consideration of inundation and damaged area of the past flood and the location of infrastructure (mainly roads along the river) and houses. The target area was the same as river survey area as shown in Fig. 3.2.11.

(2) Preparation of DEM

A DEM (Digital Elevation Model) is essential for flood simulation. In this study, the DEM for the target area was prepared as spot elevations in every 5m square. These spot elevations were digitized when ortho-photo-maps with counters were made. The flood inundation area can be analyzed by comparing the water level with the spot elevations.

(3) Prerequisite Condition

(a) N'fis, Rheraya, Ourika, R'dat and Zat River

(i) River Channel

The cross sections prepared with the interval of about 500m by topographic survey in this study were used. The cross sections were measured taking the bottleneck points into consideration.

(ii) Distribution of Discharge and Manning's Roughness Coefficient

Generally, the river discharge increases downwards in the mountain area by collecting discharge from the tributaries. The discharge distribution of the river at every probability, which is summarized in Table 3.2.6, was determined based on the observed discharge data at the principal stations in the past and specific discharge estimated from Creager Curve.

(iii) Water Depth at the Starting Point of Calculation

The river section at the starting point of calculation was assumed to give the hydraulic critical water depth, taking into consideration the steep riverbed slope at this river section. The water levels corresponding to various discharges at this point were determined by a hydraulic formula.

(b) Issyl River

(i) Hydrographs at the Boundary

Hydrographs were given for every probability with consideration of the hydrographs determined in the DRHT report entitled "ETUDE DE GESTION DES RETENUES ET DE PRODUCTION DES BERGES MISSION I ". The hydrograph is shown in Fig. 3.2.12.

(ii) Bridges

At the downstream from Sidi Youssef Ben Ali, there are three arched bridges that are obstacles to the flow of Issyl River. In addition, a bridge where Road N9 intersects the Issyl River reduces the flow capacity of this river. These bridges are shown in Fig. 3.2.13.

(4) Flood Map

(a) N'fis River

Fig. 3.2.14(1) shows the inundation area of a 100-year flood. The relative height of the road (Route 203) and houses to the river surface is so large that its hardly suffers from flood of the N'fis River. According to the Fig. 3.2.14(2), in the upper basin of the N'fis River, the probable inundation areas of a 100-year flood are the Ijyoukak and Talat-n-Yaquob villages. These villages are partly inundated when a 100-year flood occurs but not when the flood of less than 50-year occurs at Talat-n-Yaquob.

At the Wirgane River, a tributary of the N'fis River, the place near the arched bridge where Route 203 intersects is inundated in 50-year and 100-year floods. There is a possibility of inundation of houses in a 100-year flood.

(c) Rheraya River

The inundation area of a 100-year flood in the Rheraya River basin is shown Fig. 3.2.15. Especially, Route 203 between Moulay Brahim and the Asni village and Route 2015 near the downstream of Imlil Village are remarkable areas of flood inundation. The difference in height between Route 203 and the riverbed is in the range of less than 1m to 1.5 in this area. Part of Route 2015 is close to the riverbed.

Fig.3.2.16 shows the flood map around Moulay Brahim, Asni, Imlil village. This flood map shows the following. Route 203 downstream of Asni village and near the Moulay Brahim is inundated in a 10-year flood, but Asni village is partly inundated even in a 100-year flood in spite of being close to the river. Imlil village has the probability of inundation in a 10-year flood. Route 2017, which is close to the riverbed near the downstream of Imlil village, is inundated in a 5-year flood and submerges 700m in a 100-year flood.

(d) Ourika River

Route 2017 along the Ourika River is submerged for an extent of about 6km in a 100-year flood (see Fig. 3.2.17). Fig. 3.2.18 (1/5-6/5) shows the flood map near the Tnine Bridge, upstream of the Aghbalau village, near the Iraghf village (upstream and downstream), and near the Tazzitount village, respectively.

Fig. 3.2.18 (1/5) presents the flood map near the Tiguemmi-n-Oumzil village. This figure shows that the village near the right bank of the Tnine Bridge is partly inundated in a 5-year to 10-year floods and completely inundated in a flood of over 20-year probability. On the other hand, the village situated at the left bank is partly inundated in a 100-year flood.

Fig. 3.2.18 (2/5) shows the flood map at the upstream of Aghbalau village. In this area, about 1km of Route 2017 is submerged in a 100-year flood and this area has the possibility of inundation in a 5-year flood.

Fig. 3.2.18 (3/5) shows the flood map at the downstream of Iraghf village. This figure shows that Route 2017 nearby is submerged in 10-year and 20-year floods. Fig. 3.2.18 (4/5), which is the flood map near the upstream of Iraghf village, shows that a 5-year flood submerges part of Route 2017, and the area where people gather for camping, swimming and lunch is inundated in a 2-year flood.

Fig. 3.2.18 (5/5) is the flood map near the Setti Fadma village. In this area, Route 2017 and houses are partly submerged even in a 2-year flood.

On the other hand, the local consultant, INGEMA worked out flood maps of 10-year, 20-year, 50-year, 100-year probabilities in the report entitled *"Amenagements Hydrauliques pour la Protection de la Vallee de l'Ourika Contre les Crues, Mission I, Etude Hydraulique, Annexe G, November 1996 INGEMA"*. These flood maps by INGEMA are almost identical to those of this Study.

(e) Zat River

In the Zat River basin, the relative height of the road and village to the riverbed is so high that submergence by even a 100-year flood is difficult. Thus even the 100-year flood submerges the secondary road along this river with only 100m (see Fig. 3.2.19).

However, there is a very large agricultural area along the river and this agricultural area suffers from a 2-year flood.

(f) R'dat River

Fig.3.2.20 shows the submerged area of Route N9 in a 100-year flood. Some two (2) km of this route is submerged. The flood map shows that houses are also inundated in a 100-year flood, however, only a few houses are inundated except around the junction of the Tazilida tributary because they are mostly situated at more than 4m from the riverbed (the depth of this river in a 100-year flood is 3.0m on average). The houses at the village near the junction of the Tazilida tributary are inundated when the flood of over 20-year occurs (see Fig. 3.2.21).

(g) Issyl River

The 100-year flood map in the Issyl River basin is given in Fig. 3.2.22. The flood map shows the different flood characteristics between the left and right banks of the Issyl River due to the topographical condition. In the right bank, the flood diffuses widely at shallow depths due to the even flood plain, while the flood goes down through the thalweg along the river narrowly at the left bank. As a result, the inundation on the left bank is deeper than on the right bank. The maximum depth of flood is about 2.0m near the bridge where Route N9 intersects the Issyl River at Sidi Youssef Ben Ali.

3.2.5 Other Hydraulic Studies by Using Calibrated Model

By using the elaborated simulation model, some studies have been also conducted for the rivers in the study area.

(1) Examination of Muskingum Method

The Muskingum Method is a world-famous flood routing method that can be easily applied. The method is very common in Morocco too, as understood by the fact that this method was applied to elaborate the simple deterministic flood forecasting model by the local consultant, INGEMA (refer to Subsection 4.2.2). Here, an examination has been made to confirm whether the Muskingum method is applicable or not as a flood routing model in a place of the hydrodynamic model.

Fig.3.2.23 compares two discharge hydrographs for the 1999 flood that have been obtained from the hydrodynamic model and the Muskingum Method. Very good agreement is seen between them. Thus, it can be said that the Muskingum Method is good enough to be applied for the Ourika River. This result might allow application of the Muskingum Method for the flood forecasting model as discussed in Subsection 6.2.2. The calibrated parameters are given as below:

Parameters of Muskingum Method

Section	K (hour)	X
Setti Fadma – Amlouggui	0.29	0.25
Amlouggui – Tighazrit	0.65	0.25
Tighazrit – Aghbalau	0.65	0.25

(2) Estimation of Flood Propagation Velocity

Flood propagation velocity is one of the most important factors for planning a flood watch station network. In this sense, travel time of flood flow has been studied for the Ourika River through a hydraulic simulation and an interview survey on the actual 1995 flood. Consequently the flood propagation velocity is estimated at 4 m/s, considering the results of the two methods as discussed below:

(a) Travel Time by Hydraulic Simulation

The travel time of flow from Setti Fadma to the Aghbalau Station (the distance is about 16 km) is estimated about 1.2 hour by using the dynamic flow model calibrated with observed data in 1999 flood as shown in Fig. 3.2.24. The travel time corresponds to 3.8 m/s of velocity.

(b) Interview Survey on Flood Peak Time

On the other hand, the result of interview survey that was made to local inhabitants on the time of the flood peak at different locations reveals that the flood took about 1.7 hours to be propagated down 24 km from Anfli to Aghbalau. The travel time corresponds to 4.0 m/s of velocity.

(3) Estimation of Flow Capacity

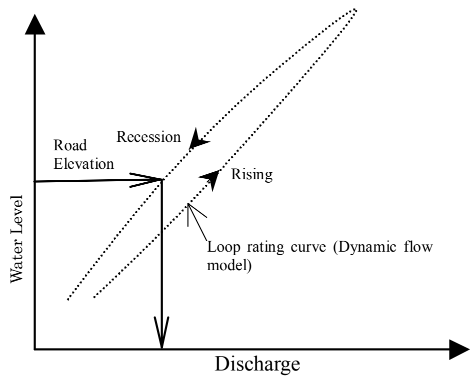
The flow capacity of the major rivers (Ourika, N'fis, Rheraya, R'dat, Zat, and Issyl) in the study area has been estimated in this section. The elevation of the road along the river has been applied as the maximum water levels for calculating the river capacity. This setting seems reasonable because many restaurants and shops stand along the road and people probably evacuate on the road during a flood.

Unfortunately, the estimation was limited to the locations with available cross section data. In order to know the flooding condition of the whole area along the river, the flood maps mentioned in Section 3.2.4 should be made as reference.

(a) Ourika River

The flow capacity of the Ourika River has been calculated from the relationship between water levels and discharges obtained for the 1999 flood simulation. The elevation of the road P2017 that runs on the left bank has been applied as the maximum water levels for calculating the river capacity.

The flow capacities at all the cross sections of the 25km stretch from Setti Fadma to the Tnine Bridge have been estimated as shown in Fig. 3.2.25(1). In the figure, the estimated capacities are compared with probable discharges with return periods of 10 and 20 years that have been roughly estimated based on the discharge records at the Aghbalau Station.



Estimation of Flow Capacity

The flow capacity at the Tnine Bridge is 650 m^3/s, which is between the 10 and 15-year discharges. This section is a critical point that is narrowed by expansion of the Tiguemmi-n-Oumzil village on both the banks. Between Tnine Bridge and the Aghbalau Station, the road elevation is very high and the flow capacities exceed the 100-year discharge. However, large agricultural areas that spread over the riverbed are exposed to a flood discharge of 20-year or over. In fact this area was damaged in the 1999 flood that had a peak discharge of 760 m^3/s at the Aghbalau Station (corresponding to the 20-year discharge).

In the upstream from the Aghbalau Station, the flow capacities are less than the 20-year discharges at some sections. Among them the flow capacity at Iraghf is as small as 160 m^3/s, corresponding to the 3-year discharge. At the upstream end the road runs in the river, and the flow capacity is almost nil.

(b) Other Rivers

The flow capacity of the other rivers has been calculated from the relationship of water level to various discharges obtained for the non-uniform flow simulation. The flow capacity is described as follows:

(i) Rheraya River

Road P2017 along the left bank of the Rheraya River was applied as the maximum water level for the calculation of flow capacity. The flow capacity at all sections of this river is shown in Fig. 3.2.25(2). This figure shows the area around the downstream of Imlil, the nearby downstream of Asni village and the upstream of the Tahanaout Station. The minimum flow capacity nearby the downstream of Imlil, where the road is close to the riverbed, is 28.5 m^3/s which is between a 2-year and 5-year discharge. Near the downstream of Asni Village, the minimum discharge is 300m^3/s which is between a 50-year and 20-year discharge. The Tahanaout Station section has the flow capacity of only 240m^3/s which is about a 20-year discharge.

(ii) N'fis River, R'dat River and Zat River

The route along these rivers has enough relative height and hardly inundated except for a few points in a 100-year flood. The flood condition in such areas should be referred to the flood map.

(iii) Issyl River

The bank of the Issyl River was applied as the maximum water level for the calculation of flow capacity. The flow capacity at each section of this river is shown in Fig. 3.2.25(2). The Issyl River has two bottleneck points. One point is around the junction with the Tassoltante tributary that has a narrow section (flow capacity is 45.8m^3/s) compared with the downstream and upstream sections (flow capacity is over 200m^3/s). The other point is the bridge where Route N9 intersects the Issyl River, which point has the flow capacity of 75.4m^3/s (under 10-year discharge). In addition to these points, there is the arched bridge with a small flow area having the flow capacity of under a 10-year discharge at Marrakech.

3.3 Social Analysis

3.3.1 Methodology of Interview and Questionnaire Surveys

Social study was conducted in May and June 2000 by means of questionnaire and direct interview with people in selected douars damaged by flood or vulnerable to the attack of natural disaster. Discussion and coordination with DRHT counterparts as well as local authorities concerned have been made in an effort to achieve study objectives. Practically, the interview and questionnaire surveys started on May 5th, 2000 and ended on June 20th of the same year in collaboration of DRHT personnel in Marrakech.

The survey approach has been carefully considered particularly for determining number of samples and selection of proper douars. These are fundamental factors in carrying out an effective work in a limited period for an extensive study area. In this regard, further details are described as follows:

(1) Identification of Flood-damaged Douars

Number of flood-damaged douars and their respective locations need to be identified prior to the commencement of field survey. In fact, this work is hardly achievable without cooperation of Al Haouz Province. Therefore, the letter was delivered to the province through DRHT asking for a listing of douars that have been damaged by floods and are susceptible to floods. By keeping a close contact with the Province, information has been received in facsimile from local authorities addressed to the governor. The basic information was obtained in such a way by relatively quick action of the local authorities, and it is confirmed that there are 250 flood-damaged douars and 152 are menaced by floods over the extensive area of Al Haouz Province (refer to Table 3.3.1). In general, floods have not claimed many lives of local people but caused damage to their lands and rural infrastructure. However, the damage magnitude has not been clear enough.

(2) Selection of Douars for the Survey

In view of the fact that there are a great number of villages listed in flood-damaged douars as mentioned above, douars need to be selected to provide suitable number for conducting interview and questionnaire surveys. It should be noted that douars in Cercle Amizmiz can be removed from eligible villages for the survey as those are located outside the boundary of study basins. Judging from time constraint and accessibility to Douars, the target number of samples was set to be 500, which may be considered as a required number to assure statistical reliability.

Based on discussions with local authorities and a document titled "*Identification des Zones Inondables dans la Province d'Al Haouz*" prepared in 1996 by Al Haouz Province, 34 douars have been selected for the interview and questionnaire surveys. This number is determined in such a way that one full day will need to be spent for the survey at each douar and 15 samples are supposed to be collected on the daily average. As the survey team is composed of five *enquêteurs*, daily working capacity is limited, and according to the experience in preliminary survey, 15 samples may be optimum and reasonable number as a daily-based sample collection.

In selecting the above douars, following conditions were taken into consideration and mutually agreed between the survey team and local authorities concerned:

- Being seriously damaged by the disaster of 1995 and/or 1999,
- Being struck by disaster caused by flood rather than debris flow,
- Providing relatively easy accessibility to the site, and
- Being typical and representative community in the area from cultural and socioeconomic points of view.

List of douars selected as such is given in Table 3.3.2 and their respective locations are shown in Fig. 3.3.1.

(3) Major Components of the Survey

Question form for both interview and questionnaire was tentatively prepared expecting to collect information about social characteristics as well as public awareness of natural disaster. In this connection, flood years in question are limited to 1995 and 1999 for the convenience of survey because these two years are notorious for giving heavy blows to the local people and still fresh in their memory. The form of the interview is somewhat different from that of questionnaire and is composed of mainly four sections, i.e. (1) general information of the family or village, (2) land ownership, (3) socioeconomic situation, and (4) flood information. Spaces are provided particularly in the last section for detailed description.

For interview survey, three samples need to be collected from each douar, and a chief of village, so called *Moquadem* and two residents have to be selected for this purpose. It is anticipated to gather detailed information on the 1995 and 1999 disasters. In addition, the situation of rural infrastructure and flood damage magnitude can be made clear at small community level through the interview with the chief of village.

For questionnaire, on the other hand, twelve samples are required from residents selected at random in each douar. Optional answers are provided in the form so it seems that questions are rather simple and clear for respondents if compared to those for interview. The questionnaire also contains four major subjects. These are related to (1) household economy, (2) details of reaction to 1995 and 1999 disasters, (3) damage experience and its magnitude, and (4) perception of natural disaster.

From the above considerations, preliminary survey was conducted in three different douars by keeping a pace of one village a day. It is an unavoidable step for *enquêteurs* to have an idea of the way of questioning. Through the 3-day trial survey, questions were occasionally modified and adjusted for respondents to get interested in the questions and to make proper answers.

The form of interview survey and finalized questionnaire were both submitted to DRH on May 2 for approval, and real survey began on May 5 with Douar Tiguemmi in C.R Ourika.

3.3.2 Result of Interview and Questionnaire Survey

Field survey has been successfully completed in the 34 selected douars as mentioned in the previous section, and total number of collected samples is as many as 513, out of which 411 are answers to questionnaire and the rest are from the interview. Knowing the fact that illiterate rate is quite high in this study area, man-to-man interview system was adopted even for questionnaire survey, and as a result all delivered forms were filled in and returned to the team without any exception.

Essential data and information were extracted from collected samples and inputted into computer to facilitate analysis work. By going through such a process, social environment, economic situation and public awareness of natural disaster can be made visible. Based on data produced by the sample analysis work, the survey results can be described as follows:

(1) Social Environment

Information on rural infrastructure and social environment was assembled through the interview survey with a chief of each selected douar called *"Moquadem"* or *"Cheikh"*, and general characteristics of the community in terms of social environment are summarized as follows:

- Transportation service is available only in 23 douars where artery road is passing nearby. In general, the sevice is not officially authorized and may be rendered a few times a day for village people by privately owned vehicle(s).
- Among 34 selected douars, dispensary is found in 6 sites only. These are locations where medical doctor or local authority is living, or social infrastracture is relatively developed to provide better living environment just like Imlil where there is neither doctor nor local autority but a midwife.
- Primary shcool can not be found in 9 sample douars, but children go to school in the neighboring village which is generally a few kilometers away from their own. With regad to number of classes, it varies depending on community scale. There are only 1 to 2 classes in small douar, but on the other hand it is likely to be a large Douar if there are more than 5 classes such as Centre Asni, Talat N'Yakoub and Arba Tighedouine.
- Although rural electrification is now in process of development in the province, there are 16 non-electified villages accounting for 47 % of the total number of sampling sites.

Electrification seems to be more difficult for villages located more than 1 km away from the trunk road.

- Main sources of drinking water are spring and wells. Basically water is rich in both quality and quantity all year round except some douars such as Ait Ben Aamr, Anrar, Tachdirte. River water is also being used for drinking water in some communities of C.R Setti Fadma, but local people express the concern about quality deterioration in mid-summer due to solid waste discharge by tourists. River water is playing an impotant role in supplying irrigation water by open ditch canal called *"Seguia"*. Water supply system by ONEP is installed only in Moulay Brahim and Sidi Youssef Ben Ali.
- For urgent communication with local authority, telephone can be used only in 6 Douars among the said sampling sites in the province. Should a caidat office be located in the same douar such as Arba Tighedouine, Centre Asni and Talat N'Yakoub, it will be certainly much easier to get in touch with him at any time. However, for communities situated several kilometers away from the route, people have to walk or take a ride on mule or bicycle down to the road and then make use of transportation service therefrom to the caidat office.
- As many people visit to spend their summer holidays in Setti Fadma in the Ourika River Basin as well as Asni and Moulay Brahim in the Rheraya River Basin, tourist business is being activated as an important income source of the local residents. Therefore, hotels, restaurants and other tourist facilities are provided for visitors coming from every part of the country and even from Europe.

Based on the above information, social environment is further summarized at each douar level and it is presented in Table 3.3.3.

(2) Household Economy

From 411 samples collected by the questionnaire, information on household economy is made available to help represent characteristics of rural economy in the study area. In general, the answer to questionnaire was given by the chief of each household selected by random sampling method.

Agriculture is predominant in the study area as the base of regional economy so respondents are basically farmers being engaged in small-scaled agriculture. However, agricultural income is apparently insufficient to make their living. Under these circumstances, their lives can not be guaranteed without resort to income from other sources. The average of household economy in the Province is shown below:

Annual income	: 20,763 Dh	Annual expenditure	: 19,958 Dh
Agriculture	: 12,338 Dh	Foods	: 14,604 Dh
Non-agriculture	: 8,425 Dh	Others	: 5,354 Dh

Further details on household economy are presented in Table 3.3.4, and based on these data and information, current economic situation in the study area can be explained as follows:

- An average household consists of 6 to 9 persons. This number has been proved by 203 respondents accounting for 49 % of the total number of samples, and followed by 10 to 14 persons as a result of 102 respondents which correspond to 25 % of the same.
- Agricultural income is estimated at 12,338 Dh a year corrsponding to about 59 % of the total annual income. This amount is insufficient for a family to survive on and even too small to cover up for food expenditure.

- Income sources other than agriculture are indispensable for almost all families to live on. Some communities in Setti Fadma and Asni can benefit from tourist business, and their earnings may be more than agricultural income. For the rest of communities, people defenitely need to get employed to support family regardless of whether permanently or non-permanently.
- Although people are engaged in agriculture, annual spending for foods is estimated to be 14,604 Dh. This figure will account for 73 % of the total expenditure and shows a very symbolic farming situation of the study area that crop production is hardly enough to achieve self-sufficiency.
- Meanwhile, food expenditure is only 5,202 Dh a year for an average respondent of Sidi Youssef Ben Ali, which is about 30 % of total annual spending. It is likely to be underestimated. The average income of people in Sidi Youssef is 17,337 Dh, about 3,000 Dh less than that in the province. However, about 70 % of annual income is spent on other purposes to keep up with urban life.
- With regard to land scale, people in the province are farminng about 1.3 ha of land on the average. It is so called *"Melk"* or private property. Traditional irrigation system called *"Seguia"* is developed in the area covering about 2/3 of the land for cultivation of mainly barley and cash crop trees such as olive, prune, apple, cherry, etc. The land use of a standard family is classified as follows:

Total land area	:	13,324 m2
Rain-fed land	:	4,286 m2
Irrigation land	:	8,855 m2
Plantation	:	6,649 m2
Housing area	:	183 m2

- Livestock is playing major part of income source for farmers of remote area in Zerkten, Setti Fadma and Talat N'Yakoub. Flock of animals can be seen in these communities. As a result of survey, an average household in the study area owns 6 to 7 goats and 3 to 4 sheep. Cattle raising is not developed in this area, and usually one household keeps one or two cattle for milking or plowing whichever more convenient, and it also keeps one mule or donkey to be used for transportation.

(3) Perception and Reaction of Local People to Natural Disaster

This item presents description of people's reaction and consciousness of natural disaster which are based on the summary of answers to questionnaire on 1995 and 1999 disasters (refer to Table 3.3.5).

(a) Perception of Disaster

To the question *"Did you perceive possible attack of disaster ahead of time?"* 365 people answered with *"Yes"* for 1995 disaster and 349 people for 1999. This means that people who did not become aware of disaster are 91 and 64 respectively. Many of these people were probably not staying in flood-prone area or near steep tributary called *"Chaabas"* in Arabic.

To the people who answered with *"Yes"* in the above question, next question was raised to ask *"How did you perceive or get informed?"* and plural answers were received in optional way. It should be noted that local people are sensitive to unusual weather conditions in the upper river basin and symptom of disaster produced thereby. Through the past experience and by weird sound from the upper basin, a number of local people can predict the disaster at more than one hour before its occurrence. These two methods are overwhelming as traditional way of perception of disaster. It can be proved by more than 85 % of answers at both 1995 and 1999 floods. In relation to the perception, the output of questionnaire is tabulated below:

Means of Perception

Classification	1995		1999	
	Answers	%	Answers	%
1. Weather forecast of TV	2	0.5	5	1.2
2. Weather forecast of radio	4	1.0	4	0.9
3. Prediction based on past experience	192	49.2	297	69.9
4. Sound from upstream basin	140	36.0	82	19.3
5. People's shout and scream	43	11.0	30	7.1
6. Information from chief of village	6	1.5	7	1.6
7. Others	3	0.8	0	0.0
Total	390	100.0	425	100.0

In addition, time of perception needs to be cleared in a series of questions and answers to such a question are given in the following table:

Time of Perception of Disaster

Classification	1995		1999	
	Answers	%	Answers	%
1. More than 1 hour before the disaster	177	49.3	251	73.2
2. 30 min –1 hour before the disaster	64	17.8	36	10.5
3. 15 – 30 min before the disaster	45	12.6	24	7.0
4. 5 – 15 min before the disaster	55	15.3	27	7.9
5. just before the attack of disaster	18	5.0	5	1.4
Total	359	100.0	343	100.0

(b) Evacuation

According to the collected data through survey, the number of respondents who made an evacuation is 163 in 1995 disaster and 89 in 1999 disaster respectively. These figures are corresponding to 36 % and 22 % of the whole respondents about this question. However, evacuation rate becomes a little higher if the question is limited to those who perceived possible attack of disaster as mentioned above. As a result, it could be understood that about 45 % of people evacuated in 1995 after disastrous symptom had been perceived, but it was reduced to nearly 26 % in 1999 case. This can be explained that unexpected heavy magnitude of disaster struck the area in 1995.

	1995		1999	
Evacuated :	163	(36 %)	89	(22 %)
Not evacuated :	285	(64 %)	314	(78 %)
Total	448		403	

As a matter of course, evacuation scale varies depending on topographic conditions of the community and its vulnerability to the attack of natural disasters, so the collected data was again put to use for making a confirmation of flood-damaged communities. From the above consideration, the number of evacuees was classified at each commune level and also by the river basin as shown in the following table:

Number of Evacuees in 1995 and 1999 Disasters

River basin	C.R.	1995 disaster		1999 disaster	
		Evacuee	Non-evacuee	Evacuee	Non-evacuee
R'dat	Zerkten	19	20	8	14
Zat	Tighedouine	8	42	4	42
Ourika	Ourika	17	47	15	48
	Setti Fadma	49	72	28	89
Rheraya	My Brahim	4	4	1	6
	Asni	26	35	12	33
N'fis	Ouirgane	8	23	5	23
	Imgdal	18	12	9	20
	Ijoukak	2	8	1	11
	Talat N'Yakoub	0	22	0	27
Issyl	S.Y. Ben Ali *	12	0	6	1
Total		163	285	89	314

* Sidi Youssef Ben Ali was not struck by 1995 and 1999 disasters, therefore information given above is based on 1982 and 1994 disasters

To the question posed to evacuees *"When did you evacuate?"*, In case of 1995, 60 people or 37 % of evacuees answered that it was *"immediately after noticing or getting informed"*. The second most answer is *"after the occurrence of disaster"* given by 54 evacuees accounting for 33 %. These two answers go to the opposite extreme to each other in a sense of risk management. However, the same tendency can be seen for 1999.

Almost all people run or walked with family and/or neighbors. Cars or motorbikes are hardly available for the local people. These machines are, rather, not best choice for evacuation. Some people evacuated with livestock if time allowed them to do so, but most of evacuees carried nothing with them.

There is no designated evacuation area in the study area so in case of emergency, people follow the path leading to the safety place wherever most convenient to them. They certainly go up on a hill or higher location nearby and stay for a while. In 1995 flood disaster, for example, 40 % of evacuees stayed in relative's house or mosque located in or out of their village and 6 % of people stayed on the roof as a narrow escape from disaster.

(c) Warning

Although there is no sophisticated warning system in the community, About half of the people gave a warning or information to the family and neighbors immediately after noticing danger. Danger signal can be transmitted from one place to another by a loud shout of the people. In tourist places such warning was given to visitors by 55 local people at 1995 disaster and 21 people at 1999 disaster respectively. In this connection, survey data are summarized as follows:

Question: *"Did you give the warning?"*

Answer:

	1995	1999
Yes	221	152
No	172	172
Total	393	324

Question: *"To whom did you give the warning?"*

Answer:

	1995	1999
1. Neighbors	179	143
2. Family	162	132
3. Tourists	55	21
4. Villages located downstream	24	22
5. Chief of village	0	0
Total	420	318

(d) Possible Measures for Damage Mitigation

People became more cautious about flood after being struck by heavy blow in 1995 and 1999, and 144 residents or about 35 % of all respondents took some measures subsequently to mitigate flood damage. The idea is on individual basis and not at community level under the strong leadership of the chief.

Mitigation measures are apparently related to the preparation for evacuation such as securing route and place and packing things to get ready for escape from disaster. These measures are of no practical use for preventives but may be the most realistic options under the present condition.

(e) Relocation

As the present community is the identical place of origin for 371 people corresponding to 90 % of all respondents, it makes no sense to ask such a question as *"Did you know that your place is vulnerable to disaster prior to your immigration?"*. However, proper answers were returned from the rest of 10 %. Among those, 15 people answered "yes" and 26 were "no". Probably they had no choice in selecting location at that time and have been living there ever since.

In considering the above conditions, a question was given to ask whether they wish to relocate their house to the safe place. Negative answer was returned from 273 residents, which account for 67 % of all. It seems to be quite hard for them to quit their home village even though the safety is not guaranteed. Main reasons are as follows:

- Financial problem
- Land problem
- Relationship with local community
- Employment opportunity

These are realistic reasons associated with social problems. Although there are 135 people who expressed the wish to relocate their house, they know that its realization is beyond their economic capability, and in fact it is not easy since they have already established closer ties with family-like society.

(f) Restoration Work

According to the survey data, 397 people or 86 % of total respondents have participated in restoration works after disaster. These works were carried out on voluntary basis as the community is established on mutual aid system. The priority was given to the restoration of communal property, and works have been done for immediate retrieval of their life support facilities such as access road, irrigation canal, water intake and so on.

Floods caused heavy damage to the above facilities and farmland but not to private houses. Therefore, a large number of people could take part in the restoration works for the public interest. Based on sample data collected, types of restoration work are shown below:

	Type of restoration work	Number of responses
1.	House of my own	65
2.	House of neighbors	101
3.	Access road	314
4.	Schools, hospitals, etc	25
5.	Others (farmland, irrigation canal, water intake, etc)	179
	Total	684

(4) Analysis of Damage

The majority of respondents gave an affirmative answer to the question whether or not debris flow and landslide occurred in the subject disasters. However, as a result of questionnaire survey, it is not clear whether the damage was attributed to flood or other calamities.

Based on information given in the interview with the chief of village, damage scale or magnitude in the 1995 and 1999 disasters can be made clear for the selected douars of the province. Meanwhile, Sidi Youssef Ben Ali was not struck by the disaster in the said years so that information shall be based on the only 1982-flood disaster because no damage has been informed for the 1994 flood. Thus, such damage is listed at each douar level and subsequently summarized at Commune level as shown in the following Tables:

List of Damage in Selected Douars in Al Haouz Province

River basin	C.R.	1995 disaster					1999 disaster				
		Dead	Injured	House	Live-stock	Land (ha)	Dead	Injured	House	Live-stock	Land (ha)
R'dat	Zerkten	0	1	4	0	6.0	0	0	0	0	4.0
Zat	Tighedouine	0	0	0	22	158.0	0	0	0	22	160.5
Ourika	Ourika	1	0	12	0	23.5	0	0	3	0	15.5
	Setti Fadma	132	25	83	151	72.0	0	15	7	0	88.0
Rheraya	My Brahim	5	0	0	0	2.5	0	0	0	0	3.0
	Asni	2	0	10	4	54.0	0	0	0	0	8.0
N'fis	Ouirgane	0	0	0	0	30.0	0	0	0	0	4.0
	Imgdal	7	2	2	303	11.5	0	0	1	0	6.6
	Ijoukak	0	0	0	0	3.0	0	0	0	0	10.0
	T.N Yakoub	0	0	0	0	6.0	0	0	0	0	5.0
Total		147	28	111	480	366.5	0	15	11	22	304.6

List of Damage of Sidi Youssef Ben Ali Prefecture

River basin	Municipality	1982 disaster				
		Dead	Injured	House	Livestock (head)	Land (ha)
Issyl	Sidi Youssef Ben Ali	0	15	25	30	0

The 1995 disaster claimed the lives of 147 people as shown in the above list. Most are said to be tourists, but some are local residents. From samples collected by questionnaire, the number of local victims is clarified to be 6 for the dead and 9 for the injured (refer to Table 3.3.5). A number of victims are found particularly in popular holidaymaking spots of Setti Fadma such as Irghef, Aghbalou Tazitounte Asgaour.

With regard to damage to houses, the number in the above list includes 58 of partially damaged houses in 1995 and 5 of the same in 1999. Apparently the locations can be identified as heavily attacked sites which are almost the same as stated above. Meantime, Municipality of Sidi Youssef Ben Ali, part of Marrakech urban area, suffers recurrent disaster and 25 houses were damaged by 1982 flood. However, it is reported that 19 of those are small damage.

Taking a look at damage to livestock in1995, goat ranks first in the number of loss reaching a total of 332 heads followed by sheep amounting to139. The livestock loss is outstandingly high in Tizgui in C.R. Imgdal and Tiourdiouine in C.R. Setti Fadma. In 1999 on the other hand, it can be seen only in Arba Tighedouine.

Damage to the land gave a heavy impact to a great number of people. It is disclosed by the questionnaire that about 75 % of respondents had damage to their respective farmlands in 1995. The number was reduced to 64 % in 1999 but still shows high average. Damage is mainly to the cultivated land rather than plantation. In this regard, Anammer in C.R.Tighedouine was hit most seriously among all selected douars.

Besides damage listed above, many tourist facilities were also hit by floods, and hotel and cafe or restaurant were heavily destroyed in holiday spots of the Ourika, Rheraya and R'dat River Basins. Moreover, floods caused a lot of damage to water supply facilities such as water mill, water intake and irrigation canal and also destroyed road and bridges, by which communication with other communities was completely cut off.

It should be noted that numerous vehicles were flushed out by the 1995 flood. The number of lost cars is not clear but it is estimated at 200 according to the survey. Cars are owned by holidaymakers visiting to such tourist places as Asgaour, Irghef and Aghbalou in C.R. Setti Fadma as well as Imlil in C.R. Asni.

Regarding valuable information given above, further details are provided in Tables 3.3.6 and 3.3.7.

(5) Local Interest in Flood Forecasting and Warning System

From the past dreadful experience local people are cautious about natural disaster, and therefore positive answer was given by about 83 % of respondents to the question whether they want to participate in evacuation drill. This kind of drill has never been practiced in any community in the study basin.

People also expressed an interest in some technical system in order that predictive flood information can be disseminated to them in advance. Naturally, they are not familiar with flood forecasting and warning system but expect some measures to be taken by the Government for the protection of their lives and property.

In considering of the above, a question was raised to ask if flood forecasting system is necessary for their village, and answer with *"Yes"* was received from 465 people accounting for 97 % of all respondents. Among them 380 people answered that they are willing to contribute themselves to the task of operation and maintenance of the system if required.

For further detailed description about contribution, the type of services is provided in the questionnaire to be at their option and plural answers were accepted in this connection. As a result following answers were obtained:

Type of contribution	Answers
1. To be voluntarily engaged in radio communication during flood period	278
2. To keep watch on communication equipment	244

3.	Any possible work if required	45

CHAPTER 4. FLOOD FORECASTING AND WARNING SYSTEM BEFORE IMPLEMENTATION OF PILOT PROJECT

4.1 Introduction

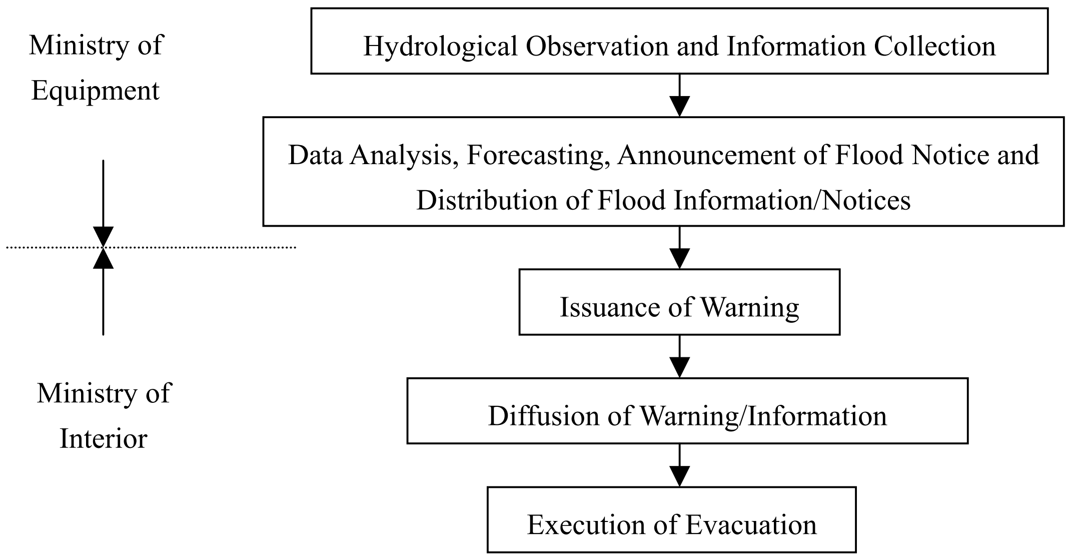
The Flood Forecasting and Warning System in the Atlas Region has been changed drastically, especially in the Ourika Valley, through the implementation of the Pilot Project between 2001 and 2003. In this Chapter, however, the previous system that used to exist before the installation of the Pilot Project Phase-I in December 2001 is explained to help understand the situations before the Pilot Project, which the draft master plan in Chapter 6 aims to improve. It is also noted that at that time ABHT was DRHT, and both of DGH and DRHT (ABHT) were under the Ministry of Equipment.

4.2 Agencies Concerned for FFWS

4.2.1 Components of FFWS

The purpose of a flood forecasting and warning system (hereinafter referred to as FFWS) is to diffuse a flood warning to people in flood prone areas, so that they can be evacuated safely in time. A total flood forecasting and warning system is generally composed of five subsystems and operated in the following procedure:

Firstly hydrological observation is made to detect a symptom of a flood or a debris flow and/or to follow them up. The observed data are collected as well as weather information to a central station, which analyzes them to forecast future situation on floods and debris flows. If occurrence of a flood or a debris flow is anticipated, a flood notice is announced and distributed to agency concerned. Then a flood warning for evacuation is issued based on the flood notices and diffused to people in dangerous areas, who can be evacuated safely in accordance with an evacuation plan.



Subsystem of Flood Forecasting and Warning System

The FFWS in the Study Area is administratively divided into two parts, namely that for the Ministry of Equipment and that for the Ministry of Interior. The Ministry of Equipment represented by DRHT, DPE and DMN is involved mainly in technical matters including observation, data collection, analyses, forecasting, announcement of flood notices and distribution of flood information/notices, etc. The roles of DRHT, DPE, DMN have not been changed at all even after the transition of DRHT to ABHT and the reorganization of the central government in November 2002, which transferred DGH, the supervising organization of ABHT, and DMN from the Ministry of Equipment to the newly created Ministry of Land Planning, Water and Environment.

The Ministry of Interior represented by the province/prefecture and lower authorities such as cercles, caidats, etc. is directly concerned with inhabitants and tourists through warning dissemination and evacuation activities.

4.2.2 Guideline for FFWS

As discussed in Sub-section 2.8.1, after the 1995 Ourika disaster, the Ministry of Equipment prepared a guideline for flood management in December 1996. The guideline stipulates roles of the agencies, DPE/DRE, DRH, DRCR, DMN, etc., especially those of DPE/DRE before, during and after a flood.

Regarding FFWS, the ME Guideline describes special messages from DMN, courses of information dissemination among related agencies, actions to be taken according to the flood situation. In addition, names and telephone numbers to be contacted are also included in the guideline book.

On the other hand, the province/prefecture has no written guideline for FFWS, although every province/prefecture has an ORSEC Plan for rescue activities in a catastrophe. In principle the governor is responsible for security of inhabitants. The governor issues warnings based on flood information/notices from local authorities, DRHT and DPE, and then diffuses them to the relevant local authorities such as cercles and caidats in an order of the administrative hierarchy. Then, the local authorities call an evacuation directly or through cheikhas and mecadams to inhabitants and tourists. However, this procedure is not always undertaken. In emergency, each level of the authorities can issue warnings for evacuation by itself. Due to lacking of telecommunication measures, dissemination of flood warnings still relies very much on inhabitants' direct voice communication (shouts and cries).

4.3 FFWS by Ministry of Equipment

Three agencies, under the Ministry of Equipment, namely DRHT, DMN and DPE Al Haouz are mainly involved in the FFWS in the Study Area. In particular, DRHT plays the most important role among the three. DRHT is a kind of flood information center for the Study Area.

DRHT is one of DRHs, which covers the river basins of the Tensift River, Qsob River and Atlantic coastal rivers between El Jadida and Tamanar. It collects rainfall and water level information from hydrological stations, and analyzes them. If the flood is anticipated to become serious, it announces a flood notice, and distributes it to related agencies.

DMN has a variety of meteorological observation networks, advanced equipment and high technologies. DMN provides weather forecasts. In addition, DMN diffuses a pre-alert and an alert message on thunderstorms and/or heavy rainfall.

DPE is a kind of delegation office of the Ministry of Equipment at the provincial level. DPE Al Haouz was established in 1996 to concentrate more on development of Al Haouz Province that was seriously damaged by the 1995 Ourika flood. The main roles of DPE during a flood are to manage road traffics, to protect dam reservoirs, and to distribute flood information/notices to the province/prefecture.

The following table presents how much is each of the agencies involved in the FFWS of the Study Area. In this section, the existing system is described by its component, especially highlighting the activities of DRHT.

Involvement in FFWS of the Study Area by Agency

Component	Component	DMN	DRHT	DPE
Hydrological Observation and Data Collection	Hydrological Observation and Data Collection	XX (weather Information)	XXX	X
Data Analyses, Flood Forecasting, Announcement of Flood Notice, Distribution of Flood Information/Notices	Data Analyses and Flood Forecasting		X	
	Announcement of Flood Notices		XX	
	Distribution of Flood Information/Notices		XX	XX
Evacuation	Evacuation			X

Intensity of Involvement; XXX : very much, X: much, X: fair

4.3.1 Hydrological Observation and Data Collection

DGH is responsible for water management including flood forecasting and warning in the kingdom. The headquarter of DGH in Rabat collects hydrological information four times a day through a HF/SSB radio network via nine DRHs (ABHs) and two DPEs from 154 stations scattered all over the kingdom. DGH is to interpret the hydrological information and to formulate management orders for dam reservoirs and flood risk areas.

DRHT is one of DRHs, which covers the river basins of the Tensift River, Qsob River and Atlantic coastal rivers between El Jadida and Tamanar. DRHT manages 23 hydrological observation stations in its jurisdiction area. Some of the hydrological stations are equipped with a HF/SSB radio, a VHF/FM radio, and/or a telephone for communication with DRHT. Through the HF/SSB and VHF/FM radio network, DRHT collects hydrological and dam reservoir data from 22 stations in total, including those in the Tassaout River Basin which are under the jurisdiction of DRH Beni Mellal as shown in Fig. 4.3.1.

In the Study Area there are eight hydrological stations equipped with a HF/SSB and/or a VHF/FM radiotelephone. These eight stations are to function as flood watch stations that detect, follow up and report a flood to DRHT. The locations of the flood watch stations are presented in Fig. 4.3.2, and their main features are summarized in Table 4.3.1.

Flood Watch Stations in the Study Area

Station	River Basin	Catchment Area (km^2)	Observation Item	Telecommunication Measures
Aghbalau	Ourika	503	WL, R	T, H, V
Tazzitount	Ourika	347	WL, R	V
Tuorcht	Ourika	19	WL, R	V
Amenzal	Ourika	49	WL, R	V
Tiourdiou	Ourika	134	WL, R	H, V
Agouns	Ourika	-	R	H, V
Aremd	Rheraya	35	WL, R	V
I. N'kouris	N'fiss	848	WL, R	H

Observation Item; WL: Water Level, R: Rainfall
Telecommunication Measure; H: HF/SSB Radiotelephone, V: VHF/FM Radiotelephone
T: Telephone

Details of the hydrological observation and data collection system based on the these flood watch stations are discussed as below:

(1) Location of Stations

There are in the 3,453 km2 Study Area 8 rainfall and 7 water level stations that can be regarded as flood watch stations. As first understood in Fig. 4.3.2 and the table below, however, the stations are located in the Ourika, Rheraya and N'fis River Basins only. There is no station in the other three basins at all. This means that the existing flood watch system by DRHT covers only the Ourika, Rheraya and N'fis River Basins but is still blind over the other basins.

Number of Flood Watch Stations by River Basin

River Basin	Catchment Area (km^2)	Rainfall Station		Water Level Station	
		Nomber of Stations	Catchment Area/Station	Nomber of Stations	Catchment Area/Station (km^2)
R'dat	532	0	Infinite	0	Infinite
Zat	528	0	Infinite	0	Infinite
Ourika	495	6	83	5 *	101
Rheraya	221	1	221	1	225
N'fis	1,256	1	1,256	1	1,100
Issyl	421	0	Infinite	0	Infinite
Total	3,453	8	432	7	493

* Water level measurement is not done at the Agouns Station.

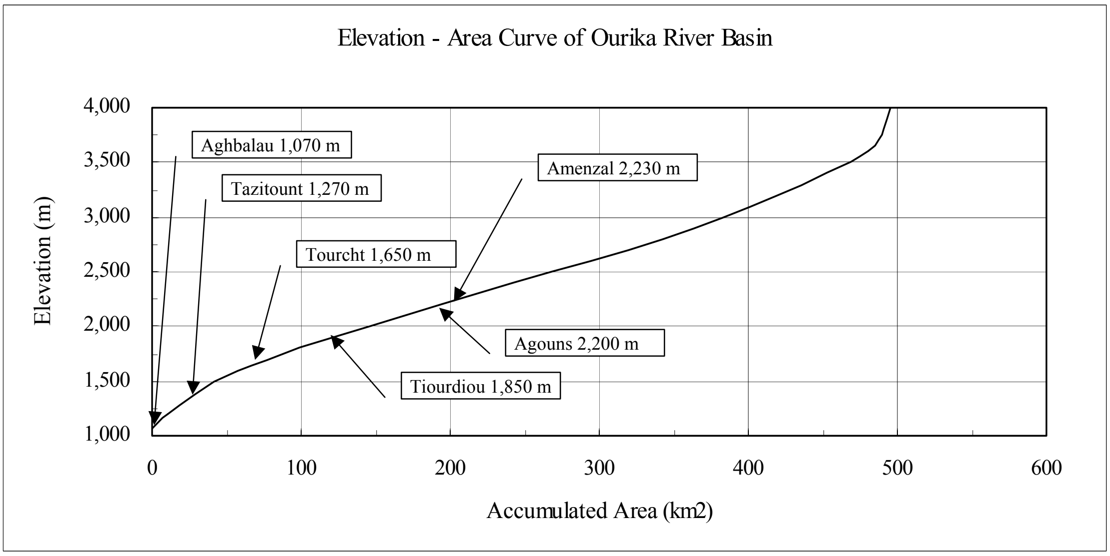
(a) Rainfall Station

A summer thunderstorm which we are very much concerned about, is characterized by intensive rainfall in space and time as represented by the 1995 disaster. Such a storm is generally composed of several active clouds with a diameter of 2 to 3 km, according to "RAPPORT GENERAL SUR L'AMENAGEMENT DU HAOUZ, LA VALLEE DE L'OURIKA, Ministry of Equipment".

The Ourika River Basin has as many as six stations because five stations were newly installed as flood watch stations after the 1995 flood. However, the average covering area by a station is 83 km^2, which still seems to be larger than the scale of such a summer storm. Moreover, the spatial distribution of the stations is not be ideal from a hydrological point of view as shown in Fig. 4.3.3. All the stations are located on or near the river or the tributaries. There is no station in the catchment areas of the two major tributaries, Tifni and Tarzaza. In addition, the altitude of the stations ranges from 1,070 m of Aghbalau to 2,230 m of Amenzal, much lower than the highest point of 4,000 m.

The locations of the stations were probably determined as a result of a compromise between hydrological requirement and practical requirement for operation and maintenance works. Difficulty of accessibility in the mountain areas is one of the most serious constraints.

On the other hand, there is only one station in each of the Rheraya and N'fis River Basin. It can be said that stations are absolutely insufficient in the two basins, although they are much better than the other three basins that have no station.



(b) Water Level Station

Since a flood flows from upstream to downstream, to keep an eye on water levels at the upstream is one of the most reliable and practical methods to know a flood in advance.

There are five water level stations in total on the Ourika River and its two major tributaries. The four stations except the Aghbalau Station were all installed newly after the 1995 flood. It can be said that the Ourika River basin became well watched with the new installation. If some more stations are added to other major tributaries such as Tarzaza, the flood watch in the Ourika River is more reinforced. The following is the estimated travel time from the stations to major tourist points:

Estimated Flood Traveling Time

To / From	Setti Fadma		Iraghf		Aghbalau St.	
	(km)	(hr)	(km)	(hr)	(km)	(hr)
Amenzal St	16	1.1	25	1.7	31	2.1
Tiourdiou St.	10	0.7	19	1.3	25	1.7
Tourcht St.	3	0.2	12	0.8	18	1.3
Tazzitount St.	-	-	2	0.1	8	0.6

Note : 4 m/s of flow velocity is assumed.

As for the other river basins, the Rheraya and N'fis River Basins has only one station. For the Rheraya at least one new station is desirable on the right tributary, Imename, to protect Asni and R'ha Mouley Ibrahim. If financial condition allows, some stations should be added to the main river and/or major tributaries in the N'fis River Basin too.

(2) Equipment

Equipment at a flood watch station is divided into that for observation and that for telecommunication. A list of the equipment is given in Table 4.3.2.

(a) Observation Equipment

(i) Rainfall Gauge

Rainfall is manually observed with a storage type gauge. This gauge requires an observer to empty the water out of the storage bucket to a cylinder for every measurement. This work seems troublesome in a heavy rain.

Frequent rainfall measurement with such an short interval of 1 hour, 30, 15 minutes is a very hard work if it must be done together with water level measurement. However, it seems that water level is given priority over rainfall. That is why rainfall measurement is in principle made only four times a day unless specially requested by DRHT. This means that the rainfall stations have not been fully utilized yet. Something shall be done so that the observers can conduct such frequent observation easily.

The Aghbalau Station has an automatic rainfall recorder that can store rainfall records continuously in a record-chart. Although such a record chart is useless for the flood watch purpose, continuous records are very precious for analyses of rainfall characteristics. Instantaneous rainfall data such as 15 minute rainfall that can be easily extracted from the chart, can be used for not only rainfall analyses but also establishment of a runoff model. Considering that there are only two rainfall recorders in the Study Area, namely one at this Aghbalau Station of DRHT and one at the Oukaimedan Station of DMN, installation of more rainfall recorders is strongly recommended.

(ii) Water Level Gauge

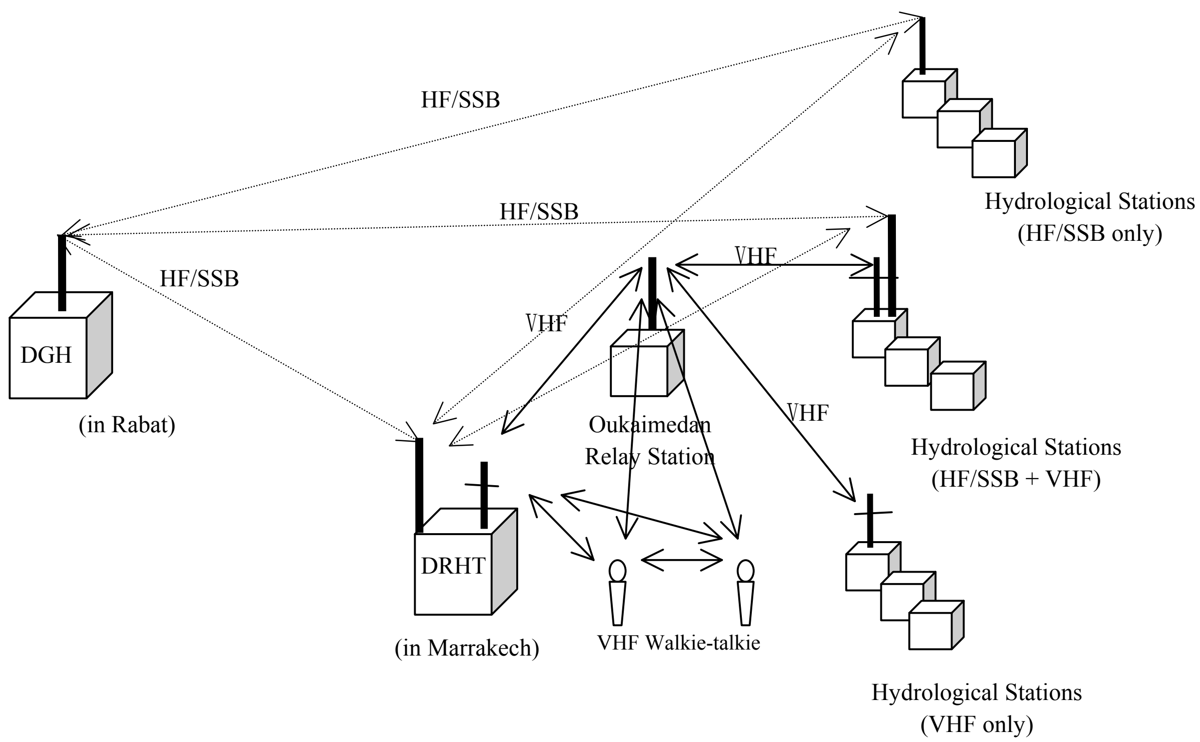
Water levels are observed manually, too. Staff gauges are fixed at the corner of the river bed. Each station has two or three sets of staff gauges. To enable reading of water level in the dark, the staff gauges are lit up with a fixed torch and/or a handy one. However, water level reading is still difficult and dangerous at night, particularly at the Tourcht, Amenzal and Tiourdiou Stations of which station houses are far from the gauges. Moreover, flood flow containing large rolling stones is so strong in the rivers that gauge scales are often washed.

The Aghbalau Station is equipped with a float type gauge with an automatic recorder, too. This type of gauge has been installed in a well that is fixed on the river bed, but the well is likely to be choked up with sands and gravel. Cleaning is indispensable after every flood. As shown in the photo, the well stands on the dry river bed and is completely choked up. According to the station observer, measurement is possible only while the water level is high enough. This problem is not only for the Aghbalu Station but also for other water level stations with this type of gauge such as the Sidi Rahal and Tahanaout Stations.

The Aghbalau and Iguir N'Kouris Stations are classified into principle stations, where discharge measurement is made once a month, namely once in the first week of every month. A cableway across the river is used to hang a 100 kg weight and a current meter during a big flood. According to a technician of DRHT, discharge measurement during a flood time used to be made until 1980's but not now. A measurement crew is dispatched from DPE Al Haouz, and from DRHT too if necessary. Results of the discharge measurement are used for establishment of rating curves for conversion from water level to discharge. The other stations are classified into simple stations, where only cross section survey is made once a year.

(b) Telecommunication Equipment

Telecommunication equipment is a strong tool for information exchange in an emergency like a flood. The eight stations have a VHF/FM, a HF/SSB radiotelephone, and/or a normal telephone to communicate with DRHT and among the stations. The VHF/FM radiotelephones were introduced for the Ourika River Basins after the 1995 disaster. The Aghbalau, Tiourdiou and Amenzal Stations are equipped with a HF/SSB radiotelephone too as a backup of the VHF/FM radiotelephone. In addition to the fixed radiotelephones, DRHT and DPE Al Haouz have respectively three and two VHF walkie-talkies that are linked to the VHF/FM network. A schematic diagram of the radio communication network is presented as below:



Radio Communication Network Link

The High Atlas that is composed of high mountains and deep valleys is quite an unsuitable place for establishment of the radio communication network. It is seemed that the radio circuit designs and the installation works at the sites were very difficult.

(i) VHF/FM Communication Network

Two channels of VHF/FM have been allocated for the simplex VHF/FM radiotelephone network that was established after the 1995 flood. The VHF/FM network has a selective call function so that a station can be called individually one by one. This selective call function is integrated with a siren that can alarm the observer.

VHF Channel Assignment.

Channel	Frequency (MHz)	Output Power
Up link	151.925	25W FM
Down link	156.925	25W FM

The service range of VHF /FM radio can reach about 40km if no obstacle exists. The distance between any two stations is not so far, but mountains stand as obstacles between the two stations. Therefore, a radio relay station had to be built on the top of the 3,200m high mountain in Oukaimeden to ensure high quality of communication. The radio relay station is composed of a 10m high self-support steel tower and a metal container to accommodate radio equipment and batteries.

Since the relay station is a kind of central post of this VHF/FM network, a damage or malfunction of the relay station easily results in a total damage of the network. However, the antenna and the solar panels are damaged several times a year by strong gusts, and interference with other networks also occurs often. It is pointed out that some renovation and reinforcement shall be necessary to solve for such problems.

(ii) HF/SSB Communication Network and Facilities

DGH has four channels (frequencies) of HF/SSB for the whole kingdom, and allocated two channels to each of the northern and southern area as follows:

HF/SSB Channel Assignment

Channel	Frequency (kHz)	Area	Operational
F1	3,625	Northern Area	At daytime
F2	4,504	Southern Area	At daytime
F3	7,342	Northern Area	At night
F4	5,799	Southern Area	At night

DRHT is included in the southern area, and two channels of F2 and F4 are used for communication among DRHT and the stations. HF/SSB is suitable for a long distance voice communication. DRHT in Marrakech and the HF/SSB stations in the Atlas Region can directly communicate with DGH in Rabat without a help of relay stations. Depending on radio propagation characteristics of the short waves, F2 is used at daytime and F4 at night.

HF/SSB radio communication is generally likely to get interfered due to its wide coverage. Regarding the existing HF/SSB network, clear communication is still maintained at daytime, but interference is sometimes observed at nighttime. The HF/SSB radiotelephone is used as a backup of the VHF/FM one at the stations that have both the two radios.

(iii) Power Supply Unit

A set of solar panels with batteries is a typical power supply unit for the radio equipment. However, the natural conditions are very severe especially for the batteries. The low temperature in winter season does not only make the batteries inefficient but also shorten their lifetimes. Frequent maintenance works including recharging by a generator are required to ensure stable power supply.

A power generator is also provided to the stations where commercial power supply is not available, except the Tazzitount and Tourcht Stations.

(c) Maintenance of Equipment

Maintenance works of equipment are generally divided into preventive maintenance and correction maintenance. The preventive maintenance is further divided into daily and weekly maintenance such as cleaning of equipment and exchange of record charts, and preventive maintenance by professionals regularly once a year or more. The correction maintenance means repair of equipment that went to into malfunction.

The observers have been so trained that they can conduct the daily and weekly maintenance. DRHT has no contract of such regular preventive maintenance with professionals. When a HF/SSB radio is broken, it is replaced by a spare radio that has been kept in DRHT. The broken radio is sent to DGH in Rabat, where it is to be repaired by its supplier under a maintenance agreement. For the VHF/FM radios, such kind of maintenance agreement has not been made yet. DRHT spent DH 50,000 for a repair of the antenna of Oukaimeden Relay Station by the supplier in 2000.

(3) Observers

As discussed in the above, observation and reporting in the existing system are basically made manually. This means that the existing system is very much depending on the observers of the flood watch stations.

The observers have been generally recruited among inhabitants near the stations. According to DRHT, it was very difficult to find eligible candidates in remote areas such as Amenzal, Agouns and Tiourdiou, where the percentage of illiterates is far over 90 %. Once they have passed the examination, they receive training from DRHT. It takes almost a year for DRHT to bring up an observer. The first half of the year is spent for a classroom training and the second half for a test operation.

The observers are paid 1,500 to 2,500 DH of monthly salary by DPE, depending on their experience. A residence house has been built for the observer's family just next to the Aghbalau, Tazzitount, Aremd and Iguir N'kouris Stations. The Agouns Station was in a room of the obserser's private residence before the present new station house was built in November 2001. On the other hand a residence house has not been provided to the Tourcht, Tiourdiou and Amenzal Stations yet, due to financial constraints. The observers of these stations must commute to their stations, walking 5 to 15 minutes on mountain trails and crossing a river and/or tributaries. According to the observers at the Tiourdiou and Amenzal, they had a bitter experience that flood water of the river or tributaries prevented them from reaching their stations in recent floods.

Administratively the observers belong to DPE, while they are actually much more related to and instructed by DRHT in their daily works. The observers are administratively out of control of DRHT, but fortunately no specific problem seems to have arisen so far on this matter.

(4) Observation and Communication during a Flood

At the flood watch stations, rainfall and water level are observed and reported to DRHT four times a day at 7:00, 11:00, 15:00 and 17:00. Then, the information is reported from DRHT to DGH in Rabat, too.

Once a symptom of a flood is perceived, flood watch is commenced. Observation and reporting of water levels is to be done more frequently even at night, every hour, every 30 minutes or every 15 minutes, depending on seriousness of the flood situation. Since rainfall measurement in a heavy rain is very troublesome as mentioned before, rainfall is not measured frequently unless specially requested from DRHT. Water levels are measured and reported so frequently until the flood has gone away.

(a) Detection of Flood

Early detection of a flood is one of the most important points of FFWS. The earlier it is detected, the more time is available for getting prepared for the flood. DRHT generally become to know a symptom of a flood from the following three sources:

- Report from the flood watch stations,
- Pre-alert and alert messages from DMN, and
- Information from DPE Al Haouz

These messages/information could reach DRHT on any day or at any hour. In DRHT, therefore, permanence is ensured even at night and in weekends to be able to receive them at any time.

The existing system depends much more upon reports from the flood watch stations for the early detection of a coming flood. If an exceptional event like a symptom of a thunderstorm is detected, the observer reports to DRHT. If DRHT has decided that following-up is necessary, DRHT commands the stations in the potential flood area to commence the frequent observation.

A disadvantage of this kind of manual observation is that a sudden flood could be missed especially at night. It is possible that the observers do not notice a noise of raindrops either a sudden rise of water levels after they go to bed. To eliminate or reduce such potential misses, DHRT must in advance inform the corresponding observers of possibility of a flood occurrence. When any break in the weather is anticipated, DRHT commands them to keep awaked and stand by against a potential flood.

In this sense weather forecasting by DMN and information of DPE are very useful. In particularly a pre-alert and an alert message announced by DMN are important. Immediately after receiving from a pre-alert or an alert message, DRHT informs the stations of the messages. Observation and reporting is to be made at 20:00 too, in addition to the four-time observation in normal times.

Besides DMN and DPE, the province and DREF that have a radio network in the Study Area can possibly become a source of flood information. Unfortunately information collection has not been made yet from the two organizations.

(b) Communication between the stations and DRHT

Communication between the stations and DRHT is made through the HF/SSB or VHF/HF radiotelephone. Since the observers at the stations and the receiver at DRHT know very well one another, the communication is considerably smooth. If a station can not be heard due to interference, the other stations can report for the troubled station instead. According to the radio operator of DRHT, he can receive reports from the 22 stations linking with DRHT in 5 minutes at the maximum.

However, it is noted that a manual error can happen every time. Errors of hearing, speaking and writing can not be eliminated 100 % as long as the system depends on this kind of manual operation.

(5) Information Collection from Related Organizations

As discussed in the above, DRHT collects or is given data/information from not only its flood watch stations but also DMN and DPE.

(a) Weather Forecasting by DMN

Weather forecasting is the most important duty of DMN. DMN conducts the weather forecasting based on numerical calculation by forecasting models, surface weather data, METEOSAT observation pictures, radar images and radio sondage data, etc. DMN releases four kinds of forecasts:

DMN releases 4 kinds of forecasts:

- Immediate and very shirt term forecast for 0 to 12 hours
- Shirt term forecast, for 12 to 48 hours
- Middle term forecast for 3 to 5 days
- Seasonal forecast for 1 to 3 months.

In addition to these weather forecasts, Special Meteorological Bulletins (SMB) are diffused to related agencies to announce some exceptional meteorological phenomena. Among the SMBs, pre-alert and alert messages on thunderstorms and/or heavy rainfall are the most important for FFWS. DRHT receives the pre-alert and alert messages through DGH and the Marrakech Synoptic Station (SDMN). Actions to be taken by DPE/DRE are stipulated in the ME Guideline, according to the alert situation as presented in Table 4.3.3.

(i) Pre-alert and Alert Messages

The pre-alert message is announced when heavy rainfall is expected. For a summer thunderstorm it is to be announced before noon, and for a winter rain 12 to 24 hours before the phenomenon.

The alert message is announced when heavy rainfall is imminently expected. For a summer thunderstorm, it is to be announced 20 minutes to 2 hours before the phenomenon, and for winter rain 6 hours before.

Type of alert, time of alert issuance, period of validity, message text, and regions concerned are included in the messages as shown in Fig. 4.3.4. Although weather forecasts are announced to the public through mass media such as televisions, radios and newspapers, but the pre-alert and alert messages are diffused only to agencies concerned as shown in Fig. 4.3.5. DMN has a system that can fax an alert message to a lot of different agencies simultaneously. DRHT receives these fax messages from DGH and the Marrakech Synoptic Station of DMN.

(ii) Frequency of Issuance and Accuracy of Alert Messages

DMN issues some 50 alert messages including pre-alert messages a year. According to a forecaster of DMN, the year 1999 was an exceptional year when about 115 messages of pre-alert and alert were announced. In October alone, 5 pre-alert and 18 alert messages were announced. Out of them, 4 pre-alert and 8 alert messages were concerned with Al Haouz Province.

Table 4.3.4 compares actual rainfall records and the 12 messages announced by DMN in October 1999, to evaluate accuracy of them. A pre-alert message and an alert one are usually issued when heavy rainfall of 20 to 30 mm or over in 12 hours is forecasted. In this context, the pre-alert and alert messages on 9, 25 and 28 October can be considered incorrect as far as the Study Area is concerned. On the other hand, the rainfall exceeding 30 mm on 26 October was missed by DMN.

DMN has been making efforts to enhance accuracy of the weather forecasting as discussed in Subsection 2.8.1. Forecasting of synoptic weather conditions became possible to some extent. However, weather forecasting for a localized area, especially in the High Atlas region still remains to be improved very much. The density of the meteorological stations is still too low in the mountain areas. The existing five radar stations can not cover the High Atlas region completely.

(b) Information Collection from DPE

DPE is also one of the sources of flood information. DPE Al Haouz has three brigades for road maintenance in the mountainous areas as shown in Fig. 2.4.1. Each brigade is equipped with a fixed VHF radiotelephone in its office. Two cars of DPE Al Haouz are also equipped with a VHF radiotelephone, and function as patrol cars. These radiotelephones are exclusive only for the DPE Al Haouz's own network, and are not linked with DRHT's VHF network.

During a flood, the brigades and cars conduct a patrol over their infrastructures. If any damage is found, it is to be reported to DPE in Tahanaut, and then to be reported to DRCR or DGH. In addition, these DPE brigades and cars can possibly function as flood watch posts, too. When a DPE brigade or a DPE car detects an exceptional phenomenon, the information is transmitted to DRHT through the Head office of DPE Al Haouz in Tahannaut.

4.3.2 Data Analyses, Flood Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Flood Notices

DRHT is responsible for interpreting of raw flood data collected from the flood watch stations, flood forecasting, announcing flood notices and distribute flood information/notices to related organizations. However, their activity on this subject is limited to conversion from water level to discharge, and nothing is made for debris flows at all.

Two simple forecasting models were developed for the Ourika River Basin in 1998, but they have never been used for an actual flood. The trend of the flood, i.e. developing or settling, is only forecasted based on information frequently obtained from the stations. Some analyses including drawing of hydrographs are done only after the flood.

(1) Conversion of Water Level to Discharge

Immediately after receiving water level data from the stations, they are converted into discharges based on conversion tables that have been previously prepared. This conversion is not so hard. It can be completed in a few minutes, thanks to the tables. These converted discharges at the principle are main information that DRHT can provide to related agencies.

The conversion tables have been made by DRHT for each set of staff gauges, applying the Manning's Formula. Discharge measurement records are used for calibration of roughness coefficients for the principle stations. For the simple station, roughness coefficients are determined theoretically. The conversion tables are updated whenever a cross section survey is made.

(2) Flood Forecasting

In terms of scientific analysis using computers, no flood forecasting is conducted. Forecasting in the existing system is completely based on information from the observers, as follows: it has started to rain, rain has stopped, water levels have begun to rise or lower, and water levels are still rising, etc. Based on the above information, the trend of the flood (developing or settling) is predicted, but no quantitative forecasting is made so far.

On the other hand, two simple models were elaborated for the Ourika River Basin in "*Amenagements Hydrauliques pour la Protection de la Vallee de l'Ourika Contre les Crues, Mission I, Mars 1996 INGEMA*". They are a statistic model and a deterministic model.

The statistic model was developed through a close analysis on hydrological data available in the Tensift River Basin. The model requires basin mean daily rainfall, a parameter of state of the basin (wet or dry) and a shower type to estimate a daily discharge volume and a peak discharge. The deterministic model was developed based on results of hydrological and hydraulic simulations. The model can estimate discharge from each sub-basin and at four control points on the Ourika River. The two models are not real time ones. Rainfall announced by a DMN message is used to estimate the peak discharge within a certain range, but they can not estimate what time the peak discharge takes place.

Flood forecasting Models for Ourika River Basin

Model	Statistic Model	Deterministic Model
Input Data	• Basin Mean Daily Rainfall • Parameter of State of Basin CN (60, 70 or 80) • Shower Type (A, B, or C)	• Basin Mean Daily Rainfall by Sub-basin • Parameter of State of Basin CN (60 or 80) • Shower Type (3 hour or 6 hour)
Output	• Maximum Discharge (m^3/s) at the downstream end	• Maximum Discharge (m^3/s) from each sub-basin and at four control point

Despite of these ambitious challenges, the two models have never been used for an actual flood, probably because the two models are still premature for the practical forecasting. It is stressed that the scarcity of instantaneous rainfall data has been hindering development of a reliable and practical forecasting model.

(3) Flood Notice

DRHT has no definite criteria of flood notices. Instead, DRHT interprets the flood information based on their experience. According to an official concerned, he has a certain value of discharge as an indicator of seriousness of the flood. For example 500 m^3/s is a critical discharge for the Ourika River. He knows that some parts of the road along the river become submerged when the discharge exceeds 500 m^3/s.

In order to respond promptly to a sudden flood, however, definite criteria like the alert messages of DMN are indispensable. Objective criteria on which even less experienced technicians can judge is necessary. As applied in the pilot project for the Ouergha River Basin, some alert levels of water levels/discharges and/or rainfalls shall be defined through hydrological and hydraulic studies. Thus DRHT can give the related organizations not only discharge and rainfall data but also seriousness of the flood classified by the alert levels.

Moreover, an action plan according to the development of the flood also shall be prepared for the related organizations including DRHT, DPE and the province/prefecture as actions to be taken by DPE/DRE according to the DMN alert messages are stipulated in the ME Guideline.

Thus the related organizations will be able to act in accordance with the common criteria based on flood information that are generally more accurate than weather forecasting.

(4) Distribution of Flood Information

DRHT distributes flood information/notices such as rainfall condition, water levels, discharges and trend of the flood (rising, finishing, etc.) to DPE, ONE, ONEP and ORMVAH as shown in Fig. 4.3.6 and as follows:

Distribution of Flood Information/Notices from DRHT

To	Communication Measure	Purpose
DPE	Telephone, Fax, VHF walkie –talkie	• Management of road traffics (maintenance, information of road cuts) • Protection of dam reservoirs • Understanding of flood conditions further to disseminate to Province, Civil Protection, and Royal Mounted Police
ONE	Telephone, Fax	• Protection of dam reservoirs
ONEP	Telephone, Fax	• Protection of water quality from sedimentation
ORMVAH	Telephone Fax	• Protection of irrigation facilities

DPE is the most important for DRHT among the above agencies because it is responsible for distribution to the province/prefecture which is concerned about security of people. According to Fig. 4.3.6, flood information/notices are given from DPE directly to Civil Protection and Royal Mounted Police too, but the distribution of flood information/notices is actually made via the province in case of AL Haouz Province. DPE is kept in touch with DRHT during a flood time. When the flood conditions are so bad, DRHT could contacts the governor of the province/prefecture directly

The information given from DPE through telephone is the one from DRHT plus the one regarding their infrastructures including traffic conditions, location of road cuts and flood damages, etc. This information is to be utilized for evacuation and rescue activities by the organizations of Ministry of Interior.

4.3.3 Evacuation

Administratively local authorities are responsible for evacuation activities. As discussed in Subsection 2.8.1, however, it is noted that Ministry of Equipment represented by DPE Al Haouz has been contributing to enhancement of security of inhabitants and tourists through the following activities:

- Studies to Identify Flood Inundation Areas
- Installation of Warning Boards
- Preparation of Brochure for Tourists
- Construction of Evacuation Facilities
- Enactment of “Water Act”(“10-95 Law”)

4.4 FFWS by Ministry of Interior (Al Haouz Province)

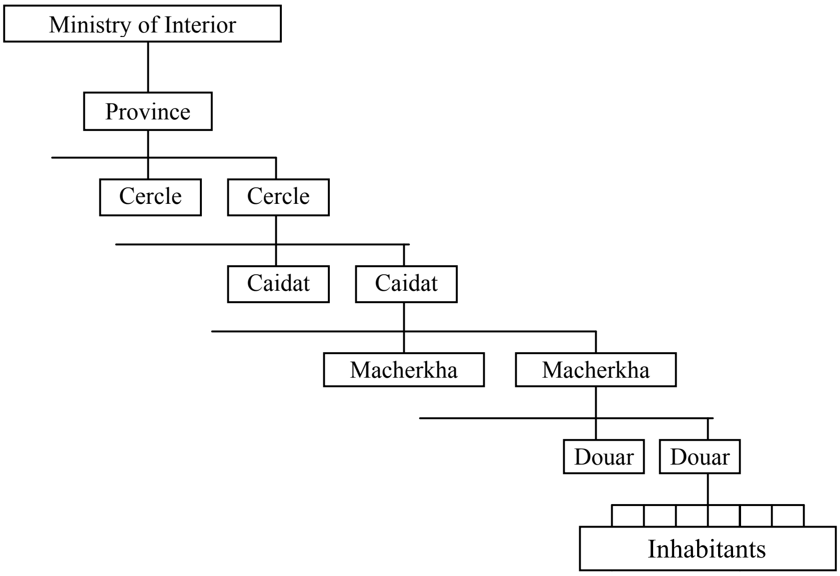
Al Haouz Province covers almost all of the Study Area, while the downstream end of the Issyl River is included in Sidi Youssef Ben Ali Prefecture. The province/prefecture and lower local authorities such as cercles, caidats, macherkhas and douars, play an important role especially in the final stage of FFWS when the inhabitants and tourists must be evacuated to safe places. Moreover, for the R’dat, Zat and

Issyl River Basins where the DRHT system can not cover, the province (and Sidi Youssef Ben Ali Prefecture for the Issyl River) alone must collect flood information.

The local authorities are all on duty permanently for 24 hours against a flood. Once an exceptional flood is detected, they are to get prepared against the flood. The main roles of the province are to issue flood warnings including evacuation warnings, to disseminate the warnings and to evacuate inhabitants and tourists. It is noted that the network of the local authorities could function as flood watch network too. In this Section, activities of Al Haouz Province related to FFWS are described.

4.4.1 Observation and Data Collection

Most of cercles and caidats are equipped with a telephone and a radiotelephone, as shown Fig. 4.4.1. Some commune rurales also have a telephone and/or a radiotelephone. These telecommunication measures enable the local authorities to function as flood watch stations. In addition, some of the local authorities are equipped with a rainfall gauge as explained in Sub-section 2.8.1.



Hierarchy of Local Authority

When something exceptional is detected, they are to contact their upper authority one by one, so that the message can reach finally the province. The administrative hierarchy is in principle respected for communication among the authorities, but exception is allowed in emergency to save time.

According to an official of the province, the first information on the 1995 flood was brought by a telephone call from Asni Caidat.

4.4.2 Issuance of Warning

There is no guideline for issuance of warnings in the province/prefecture. In principle, the governor is responsible for security of inhabitants and tourists in the province/prefecture. Although the province/province disseminates flood information/notices from DPE and alert messages from DMN to the lower authorities, issuance of warnings including a decision for evacuation is generally made at each lower authority or even at each individual level before informed, based on their own experience from the following reasons:

- Floods and debris flows are too fast,
- Communication measures are lacking, and
- Inhabitants are so familiar with characteristics of floods and debris flows in the Study Area that they can judge by themselves.

4.4.3 Dissemination of Information/Warning

For the dissemination of flood information/warnings, the hierarchy of the local authority is respected in principle. The telephone network and the radio network are used as telecommunication measures although the telephone network is less reliable during floods. From the same reasons as mentioned in the previous sub-section, however, verbal communication among inhabitants is still the most important communication measure, especially a flash flood like the one in 1995. According to the questionnaire survey in this Study, almost all the respondents were informed of the flood by upstream inhabitants in the 1995 and 1999 floods.

DMN alert messages are also diffused to the lower authorities from the province in accordance with the hierarchy. The alert messages are never given to inhabitants to avoid unnecessary panics. Receiving the alert messages, the local authorities are to reinforce their permanent duties.

Lacking of communication measures is the most serious problem for the dissemination of flood warnings. Even if a flood warning is disseminated from the governor, it can reach only caidats or communes by radio or telephone. From there, people must go by vehicle or on foot. Improvement of communication measures is essential and a siren that warns a danger of a coming flood should be installed at areas vulnerable to floods and debris flows in order to speed up the dissemination and to warn as many people as possible at a time.

4.4.4 Evacuation

Since the ultimate purpose of FFWS is to evacuate people to a safe place in time, the system is not successful unless evacuation is appropriately made. It is reported that many tourists rushed to their cars for evacuation in Iraghf during the 1995 disaster, resulting in a panic, road congestion and the tragedy of about 200 causalities. It is also pointed out that most of the tourists could not understand warnings in Berber from the local inhabitants. The number of the causalities could have been reduced if evacuation had been made appropriately.

As discussed in Subsection 2.8.1, some measures to facilitate evacuation have been made by Ministry of Equipment, namely installation of warning boards that notice that the places are vulnerable to floods, and construction of evacuation facilities. However, they are still insufficient, in particular for tourists.

Another problem is lacking of an evacuation plan. They are not shown where to be evacuated. Guiding by local inhabitants and employees of the tourism industry is indispensable but it is still unknown how much they can help tourists actually in a catastrophe.

4.5 Actual Practice in October 1999 Flood

The above descriptions about the FFWS in this region are mainly based on the ME Guideline, study reports and results of hearings and field reconnaissance. In this section, it is examined closely how the FFWS has been actually operated during a flood.

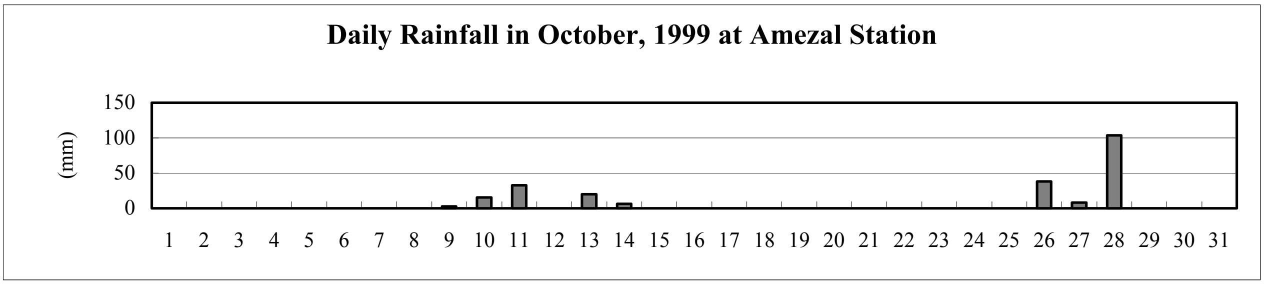
A flood on October 28, 1999 was selected as a target flood. Hydrological records were collected as many as available and a series of interviews were made with officials concerned in DRHT, DPE Al Haouz, Al Haouz Province, local authorities, DMN, etc. Then, playing-back of the situation on October 28, 1999 was challenged through arranging a mosaic of records and memories. The result is summarized in Fig. 4.5.1 and discussed as below, although the descriptions concentrate considerably on activities of DRHT for which more records are available:

4.5.1 October 1999 Flood

The Study Area experienced two floods in October 1999. The first one occurred on October 11, and the second on October 28. The second flood was more serious in terms of magnitude of peak discharges and damages to infrastructures and agriculture.

Rainfall that began on October 26 continued almost three days, giving heavy downpours to the mountainous areas on October 28. These downpours generated flood discharges in the Ourika, Rheraya, N'fis, R'dat and Zat rivers. The flood discharges were at a peak between 3 and 9 p.m. on October 28, depending on the rivers. The Ourika River had a flood peak on the lowest stretch between Tazzitount and Aghbalau from 3 to 6 p.m., according to hydrological records of DRHT. Graphs of observed rainfalls and water levels are presented in Figs. 4.5.2 and 4.5.3.

By this flood two houses in Aghbalau were washed away and the P2017(Marrakech-Setti Fadma road) was cut at many locations. Electricity lines in Aghbalau were cut and telephone communications were disturbed in the whole Ourika. Fortunately, however, no causality has been reported.



4.5.2 Playing-back

Based on the collected information, activities of each of the related organizations were played back as follows:

(1) Before October 28

Rainfall started in the afternoon on October 26 and continued 3 days intermittently. During the first two days, the rainfall was not heavy enough to generate a flood. Main activities in this period were rainfall forecasting by DMN and flood watching by DRHT.

(a) DMN Alert Message

Between October 26 and 27, DMN announced two pre-alert/alert messages as shown below. These messages were diffused by fax to the related organizations, DRHT, DPE, Al Haouz Province, etc.

DMN Alert Message

Type of Message	Time of Issuance	Valid Period of Message	Message Text
Pre-alert	14:00, Oct. 27	From 15:00, Oct. 27	Very dense cloudy masses will concern the regions and will cause precipitation of which intensity might exceed 20 mm in 12 hours. Some overflowing on the neighboring plains is probable. Winds might exceed 80km/h in some places.
Alert	18:10, Oct. 27	From 18:00,Oct. 27 to 8:00, Oct. 28	Very dense cloudy masses will concern the regions and will cause precipitation of which intensity might exceed 40 mm in 12 hours. Some overflowing on the neighboring plains is probable. Winds might exceed 80km/h in some places.

(b) DRHT

Even in this period, DRHT was conducting close flood watching to detect any symptom of a flood. In addition to the periodical observation, frequent measurement and reporting of water levels were being made as often as every one hour or every 30 minutes for the Aghbalau and N'kouris Stations. The collected information was immediately disseminated to officials in DPE AL Haouz through the telephone and the VHF radiotelephone.

On the other hand, problems arose at some stations. The Tazzitount Station could not help reducing the number of times of reporting because the radio batteries were being exhausted. The batteries could not be recharged due to a breakdown of the regulator of the solar panel. At the Amenzal Station measurement of water levels was impossible because scales of staff gauges had been washed away by the flood on October 11.

(c) DPE Al Haouz

The main activity in this period was reinforcement of permanence for following up and collection of information on the flood and road conditions. DPE Al Haouz was in close contact with DRHT and its brigades for road maintenance through the telephone and the VHF radiotelephones. In addition, a PC was established in DPE, receiving the DMN alert message.

(d) Al Haouz Province and Ourika Caidat

The main activity in this period was diffusion of the DMN alert messages. According to the hierarchy of the local authorities, the messages from DMN were diffused to the lower authorities.

(2) October 28

The rainfall became heavier from about 6 a.m., and accordingly discharges began to swell. The rainfall continued till 7 p.m., recording daily rainfalls over 100 mm at the Amenzal, Tourcht and Aremd Stations. A flood peak appeared between 3 and 6 p.m. on the lowest stretch of the Ourika River (Aghbalau to Tazzitount). According to DRHT, the peak discharge was estimated at 762 m^3/s at Aghbalau.

Each of the related organizations responded to the flood within its responsibility. DRHT collected rainfall and water level data and analyzed them, and then DRHT distributed to DPE Al Haouz a kind of flood notice. DPE closed the gate at Aghbalau on the P2017 to control the traffic on the damaged road, based on the notice from DRHT. This notice was distributed through DPE to Al Haouz Province. Then it was disseminated as a flood warning by the province to the cercles. Receiving the warning from Tahanaout Cercle, the Ourika Caid patrolled flood risk areas.

(a) DMN Alert Message

Two alert messages were announced by DMN on October 28, as shown below. These messages were diffused by fax to the related organizations, DRHT, DPE, Al Haouz Province, etc.

DMN Alert Message

Type of Message	Time of Issuance	Valid Period of Message	Message Text
Alert	8:30 Oct. 28	Till 12:00, Oct. 28	Very dense cloudy masses will concern the regions and will cause precipitation of which intensity might exceed 40 mm in 12 hours. Some overflowing on the neighboring plains are probable.
Alert	20:20, Oct. 28	Till 6:00, Oct. 29	Very dense cloudy masses will concern the regions and will cause precipitation of which intensity might exceed 50 mm in 12 hours. Some overflowing on the neighboring plains are probable. Winds could exceed 80km/h in some places.

(b) DRHT

Officials in charge stayed late at the office until 3 a.m. last night, but they came back to the office by 7 a.m. in the morning. The operator of DRHT contacted the stations through the VHF walkie-talkie to follow up the flood situation, before leaving his house. The water levels already began to rise at the Aremd (Rheraya River) and I. N'kouris (N'fiss River) Station. Then, frequent contacts (every an hour or 30 minutes) with the stations were continued until 8 p.m., especially until 11 a.m. next day for the Aghbalau Station. Rainfall data were also reported every hour during the flood peaks and the early period of their recession, namely between 3 and 8 p.m.

On the other hand, the Tazzitount Station could not report to DRHT because the batteries had been exhausted at last. Water levels could not be measured at the Amenzal Station as mentioned in the above.

Water levels were converted into discharges based on previously prepared conversion tables. Flood information including rainfalls and discharges was distributed to DPE Al Haouz and DGH immediately after receiving reports from the stations. According to DPE Al Haouz, a kind of flood notice was also distributed from DRHT to DPE four or five hours before the flood peak of the Ourika River (estimated time is 10 a.m. to 2 p.m.). The notice was something like "There is a flood coming soon". DRHT forecasted coming of the flood based on the trend of reported water levels and rainfalls.

(c) DPE Al Haouz

DPE Al Haouz who was in close contact with DRHT received the flood notice through the telephone from DRHT between 10 a.m. and 2 p.m. DPE Al Haouz distribute the notice to Al Haouz Province through the telephone, too.

Referring to the information from DRHT, DPE Al Haouz dispatched road maintenance vehicles to damaged and damageable portions from the brigades. The flood notice determined DPE Al Haouz to close the P2017 at Aghbalau to control the traffic into the flood risk areas in consultation with Al Haouz Province.

(d) Al Haouz Province and Ourika Caidat

Judging from the interviews with Al Haouz Province, DPE and Ourika Caidat, it is guessed that the flood notice from DPE was diffused to the cercles as a flood warning.

Ourika Caidat received the warning message about 2 p.m. from Tahanaout Cercle through the VHF radiotelephone. The message was "A flood is coming soon and go to the river to take a necessary measure against the flood".

Then the caid drove his car to Iraghf where hundreds of people were killed or injured in the 1995 disaster. On the way he patrolled flood risk areas along the rivers to call an evacuation from the river with a loudspeaker. Fortunately nobody was in the river because of the rainfall from the morning. He arrived at Iraghf about 2:30 p.m., where he gave instructions to a cheikha, mecadams and the Auxiliary Force who had gathered. He stayed there until 9 p.m. when the flood risk was already over.

The total time spent on the notice/warning dissemination from DRHT to inhabitants in Iraghf is estimated approximately at 50 minutes if the dissemination between two organizations was made in five minutes. It is clear that the final stage of the dissemination, namely from the caid to the flood risk area wasted a long time of 30 minutes. If the caid had driven to Setti Fadma for warning too, he would have taken 30 minutes more.

Time Spent on Flood Notice/Warning Dissemination

Notice/Warning Dissemination	Time (min.)	Accumelated Time (min.)
DRHT to DPE (Telephone)	5	5
DPE to Province (Telephone)	5	10
Province to Cercle (Telephone or VHF radiotelephone)	5	15
Cercle to Caidat (VHF radiotelephone)	5	20
Caidat to Iraghf (by car)	30	50

4.5.3 Evaluation of Observation and Data Reporting by DRHT

As discussed in Subsection 4.3.1, the DRHT system depends very much upon manpower. Observation and data transmission are all made manually. In this Subsection, an evaluation on these manual operations is made, using records of the October 1999 flood.

(1) Accuracy of Water Level Measurement

Water level observation is a very hard and dangerous work especially during a flood time. An observer must go down on slippery mountain trail in heavy rain to read water level, and then go back to the station on the same trail for reporting to DRHT. He must do this every an hour, 30 minutes or even 15 minutes if necessary.

It is natural that the observers make a mistake under these difficult conditions. In fact, some strange and doubtful data are found among the water level records observed in the flood, as shown in Fig 4.5.4 and summarized as below:

Strange or Doubtful Water Level Records

Station	Comments
Aghbalau	Mismatch of peak times of the two measurements at.B1 and B3 gauges
Tourcht	Graph shapes are totally different between the two measurements at B1 and B3 gauges.
Tahanaout	The measurement was suspended because the observer had to be evacuate from the flood.

(2) Reliability of Data Reporting

To examine data agreement between the observed records at stations and the received data at DRHT, water level data at the following three stations were used. Each observed water level on the record sheets of the stations was compared with the corresponding water level record at DRHT. Results are summarized as follows:

Percentage of Agreement

Station	Number of Data	Number of Agreed Data	Percentage of Agreement
Aghbalau	63	63	100.0
Tiourdiou	43	42	97.7
I. N'Kouris	14	12	85.7
Total	120	117	97.5

Among the total 120 data, disagreement was found for three data, and the maximum difference is 40 cm. The percentage of agreements is 97.5 %. These disagreements were probably caused by writing/reading errors of the observers or listening/writing errors of the radio operator. Although this examination is based on 120 data only, it can be said that such a human error is inevitable as long as the manual operation is made.

4.6 Actual Practice in 12 August 2001 Flood

4.6.1 Introduction

In the afternoon of Sunday, 12 August 2001, a small flood took place in the Ourika Valley. Fortunately the flood was so tiny that neither dead nor injured casualties have been reported although there were many holiday makers enjoying the summer weekend and the Moussem(yearly feast for commerce and entertainment) in the valley. The major damage was a traffic block caused by debris brought from tributaries, which was nearly cleared after a few hours by the DPE road maintenance brigade. No damages to properties have been reported except for light damages of a taxi car that was hit by debris.

The small flood is not significant in terms of hydrology but very important for those who are involved in the disaster management. The flood can be regarded as a precious sample to examine the actual practices of the FFWS in this region. Thus an examination similar to the one made last year for the 1999 flood was attempted through data collection and a series of interviews to officials concerned in DRHT, DPE Al Haouz, Al Haouz Province, Royal Mounted Police and Civil Protection and to local inhabitants in Iraghf and Setti Fadma. The results are summarized in Fig. 4.6.1.

4.6.2 Hydrological Condition

(1) Rainfall

It was fine in the morning, and clouds began to develop after noon. Then it began to rain around three o'clock and the rainfall lasted about 1.5 hours with intermittent strong downpours.

The daily rainfall distribution is presented in Fig. 4.6.2. The Tazzitount Station recorded the heaviest rainfall of 32.0 mm, followed by the Aghbalau Station of 18.8 mm. The Amenzal and Tiourdiou Stations had about 4 mm of rainfall, but the other two stations, Agouns and Tourcht had no rainfall. From these records and results of the interview surveys, it is estimated that heavier rainfall concentrated on the downstream area of the valley between Aghbalau and Setti Fadma.

The rainfall chart of the Aghbalau Station alone gives us a precise duration and intensity because the other stations are not equipped with a rainfall recorder. According to the chart, the rainfall started at 1445 hours and lasted until 1715 hours with an intensive downpour of 8.9 mm in 10 minutes between 1450 and 1500 hours as shown in Fig 4.6.1. Although the total rainfall quantity of 18.8 mm is not so significant, the high intensity that corresponds to 53.4 mm/hour is noteworthy.

(2) River Discharge

Water levels were observed at the Aghbalau and Tazzitount Stations as shown in Fig 4.6.1. The water level started to rise around 16 o'clock and reached the peak around 1630 hours, about 40 minutes later than the rainfall peak at Aghbalau. The peak discharges were estimated as small as 22 m^3/s for Aghbalau. The flood period was very short and returned to the initial condition by 19 o'clock.

(3) Debris from Tributaries

The rainfall quantity was not enough to develop large river discharge but its strong intensity generated sediment discharge on the tributaries between Aghbalau and Setti Fadma. The left tributaries spit out debris on the Marrakech-Setti Fadma road (P2017), resulting in blocking the traffic. The debris was almost cleared by the DPE road maintenance brigade by 22 o'clock.

4.6.3 Activities of Organizations Concerned

Through a series of interviews in late September 2001, activities of the related organizations during and after the flood could be guessed to some extent. The followings are results of the playing-back based on not written records but memories of personnel concerned. Therefore, it is noted that the following description might contain some errors, especially those for timing.

(1) DMN Alert Message

Forecasting of summer storms seems really difficult. Nothing special had been mentioned for the weather on 12 August of the High Atlas in the Mid-Term Meteorological Forecast that had been issued by DMN two days before, on 10 August. Neither a Pre-alert nor an Alert message had been announced before the flood, and it was at 1850 hours, about two hours later after the flood when DMN announced an Alert Message over areas including the High Atlas. Moreover, it did not rain at all in the Ourika Valley after the announcement in spite of the Alert message warning of rainstorms exceeding 30 mm in 6 hours in the following 21 hours. The Mid-Term Forecasts and the Alert Message on 12 August are attached herewith.

(2) DRHT

It is the Aghbalau Station who first informed DRHT about the flood. To report the development of the flood, the station observer telephoned around 16 o'clock the mobile phone of the radio operator of DRHT who was at home. Receiving the report from the Aghbalau Station, the radio operator rushed to DRHT and communicated with the flood watch stations except the Tazzitount Station of which radio was out of order as soon as he arrived around 1630 hours. The radio operator soon understood that the flood was not so significant, but he kept contacted with the Aghbalau Station until 20 o'clock to follow up the flood situation.

The chief of the Service of Planning and Management of Water who was off on the day also came to DRHT around 17 o'clock for fear of a possible rainstorm, seeing the dark sky in Marrakech. The radio operator and the chief decided that it was unnecessary to inform the related organizations about the flood.

On the next day DRHT dispatched a technician to the valley to collect information on the flood situations and to conduct river cross-section surveys. Results of the reconnaissance were summarized to an one-page report.

(3) DPE

The Aghbalau Station of DRHT telephoned DPE too. A technician of the Infrastructure Service who was on duty received the call from the Aghbalau Station around 16 O'clock. Since the station explained that the flood was not important, he never disseminated the information to any other organizations.

Receiving a request from the Al Haouz Province, DPE dispatched around 19 o'clock to the Ourika Valley their road maintenance brigade stationed at Oukaimedan for clearing debris from the road. The brigade could nearly cleared debris by 22 o'clock in the evening, although they continued their work on the following day.

(4) Province

The Province was informed between 16 and 18 o'clock by the Royal Mounted Police and the local authorities including the President of the Setti Fadma Rural Commune. Immediately after informed, the Province requested the Royal Mounted Police and the Auxiliary Force to mobilize their brigades to the valley. The Province also sent there the Super Caid of the Tahanaout Cercle in place of the Ourika Caid who was on summer vacation.

(5) Royal Mounted Police

The Royal Mounted Police was informed about the flood around 16'o'clock by its patrol car sent to the Ourika Valley, which is to be stationed there during the summer tourist season. As soon as informed, the Royal Mounted Police communicated with the Province and dispatched reinforcements to the valley from its Ourika Brigade.

(6) Civil Protection

The Regional Commandment of Civil Protection had not been informed at all, and he was very much surprised to read a newspaper article on the flood, of which exaggerated descriptions about the flood damages were pointed out by the Province later. According to him, the reason why the Civil Protection was not informed is that the flood was so small that no causalities were reported.

4.6.4 Reactions of Tourists and Inhabitants

This year's drought almost dried up the Ourika Valley this summer, and hotel and restaurant employers were having a hard time with decrease of visiters, who long for clean and cool water in the valley. Nevertheless, there were thousands of holidaymakers along the valley on that day, 12 August when the weekend coincided the Moussem at Setti Fadma.

The followings are summaries of interviews to shop owners and hotel employees made on 2 October 2001 regarding reactions of tourists and inhabitants to the flood:

(1) Setti Fadma

When the rainstorm broke around 4 o'clock, the Setti Fadma area was crowded with thousands of tourists who were enjoying the Moussem. Reminded of the 1995 flood tragedy, many tourists got confused or agitated by local young boys, while local inhabitants were comparatively calm.

Most of the tourists who came by their private cars rushed to their cars to escape from the dangerous valley. At the beginning of the rainfall, cars managed to escape from the crowded tourist place with less difficulty. Once left tributaries brought debris onto the road at several places even in the Setti Fadma area alone, the flow of cars became slow drastically, resulting in heavy traffic congestion.

On the other hand, a large number of tourists were lead to douars behind the tourist place by shop-owners and employees who are local inhabitants. They spent a few hours at the inhabitants' houses, waiting for the situation to settle. Some shop-owners closed their shops to evacuate themselves and tourists or got prepared for evacuation so that they could escape at any time.

(2) Iraghf

The Iraghf area was also crowded with tourists. Once it started to rain around 3 o'clock, tourists escaped to restaurants along the road. Some tourists went home by their cars.

As the rainfall became harder, the Tighezrit Tributary that generated debris flows in 1995 started to pour flood water across the road. This water disturbed the going-home traffic, resulted in a heavy jam at the tourist place between 15 and 17 o'clock.

4.6.5 Lessons from the Flood

Through the above play-backing of the flood on 12 August 2001, many problems contained in the flood protection measures can be extracted. These are all precious lessons for improving the present FFWS and summarized as follows:

- Forecasting of summer storms are still very difficult even with advanced equipment of DMN. DMN possibly miss a localized summer rainstorm as the 12 August 2001 flood. Every related organization should take precaution against sudden evolution of a rainstorm especially in summer even while no DMN alert messages are valid.

- The summer rainstorm is characterized by its localized intensive rainfall. Fortunately the rainfall was too little in quantity to swell the river over the banks, but it was enough to revive the tributaries. If it had rained a little more, even debris flows could have happened on these tributaries.

- For forecasting floods and debris flows from the tributaries, rainfall observation in the tributaries' catchments is essential. On the contrary, the existing stations are all located at the bottom of the valley along the main rivers. As proposed in the Master Plan, additional installation of rainfall stations is necessary especially for those between Aghbalau and Setti Fadma.

- It is a great regret that the Tazzitount Station that was at the center of the rainfall area could not report to DRHT during the flood due to malfunction of the radio equipment. Equipment should be maintained in a good condition at any time.

- DRHT was first informed by the Aghbalau Station around 16 o'clock when the rainfall nearly ended. The timing of the report by the Aghbalau Station is considered too late against possible floods and debris flows from the tributaries, which were luckily not generated that day.

- To speed up decision-makings in emergency, criteria for necessary actions according to the flood situation should be defined in advance. Such criteria should be based on observed hydrological indicators (rainfall and/or water level) as suggested in the Master Plan. For example, with a rule "The stations must report to DRHT if any rainfall is detected" the Aghbalau Station could have reported around 15 o'clock, immediately after the rainfall started.

- Inter-ministry communication between Ministry of Equipment (DRHT and DPE) and the Ministry of Interior (Al Haouz Province) was nil except for the request of dispatch of the DPE brigade. DRHT and DPE Al Haouz did not inform the Province, while the Province did not ask DRHT for hydrological information that could have been useful for the interventions by the Super Caid and the Royal Mounted Police. Criteria should be created for the inter-organization communication too.

- The Marrakech-Setti Fadma Road, P2017 has no adequate structures crossing tributaries in the Ourika Valley. Once it rains 20 to 30 mm or more, the road is exposed to flood water and debris from the tributaries. Moreover, there are unstable steep slopes just behind the road in all the stretches in the valley, and these slopes also possibly fail under heavy rainfall, although fortunately no slope failure took place along the road in the summer flood. Structures such as bridges, culverts, tunnels, and slope protection works should be provided to protect the road.

- On the other hand, it seems wise to refrain from using cars during a flood for avoiding secondary disasters as long as the road is still vulnerable to floods. Traffic control during a flood is also one of the big problems.

- In the 12 August flood the Super Caid and the reinforcement elements of the Royal Mounted Police managed to enter the valley a few hours later after the rainstorm. They could engage themselves in inspection of the flood situation, order maintenance and supervision of debris clearing works by DPE. Since the tourist places in the valley are very far away (1 to 1.5 hours by car even in normal times) from Marrakech and Tahhanaout, what the administrations can do is limited to such post-flood activities. The administrations generally can not help inhabitants and tourists evacuate themselves at all before and during a flood. Even a warning message from the administrations can not reach the risk areas in time if an appropriate communication measure like a radio is not available.

- Under the above situations, the inhabitants and tourists are required to take actions by themselves without help of the administrations in principle. However, the tourists who are not familiar with the places and the flood characteristics get confused and agitated but for any helps by the inhabitants. Therefore, the inhabitants, especially employers and employees of the tourism industry are required to guide the tourists to safer places, as practiced in Setti Fadma on 12 August 2001.

4.7 Problems of Existing FFWS

As a conclusion of discussions in this chapter, problems of the FFWS before the implementation of the Pilot Project are extracted and summarized in the following table.

Problems of Existing FFWS for Study Area

Subsystem		Problems	Related Organization
Hydrological Observation and Information Collection	Observation	• Insufficient number and inappropriate deployment of rainfall and water level stations • Difficulties of manual observation of rainfall and water level • Improper equipment for water level measuring	DRHT
	Data transmission	• Inevitable verbal communication errors • Necessity of renovation and reinforcement of the relay station	DRHT
	Information collection	• Necessity of enhancement of accuracy of weather forecasting	DRHT,DMN
Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices	Data Analysis	• Poor data analyses • No consideration on debris flows	DRHT
	Forecasting	• No scientific forecasting • Scarcity of rainfall records for establishment of flood forecasting model • No consideration on debris flows	DRHT
	Announcement of Flood Notices	• No criteria for announcement of flood notices • No consideration on debris flows	DRHT
	Distribution of Flood Information/ Notices	• No visualized information • Inevitable verbal communication errors	DRHT/DPE
Issuance of Warning		• No criteria for issuance of warning • No consideration on debris flows	Province/ Prefecture
Dissemination of Warnings		• Inevitable verbal communication errors • Insufficient telecommunication measures • Language gaps between inhabitants and tourists • No alarm equipment such as a siren and a speaker	Province/ Prefecture and Lower Local Authorities
Evacuation	Facilities	• Insufficient evacuation and parking spaces	DPE, Province/ Prefecture, and DRT
	Operation	• Language gaps between inhabitants and tourists • No designation of evacuation places • No organization for assistance to tourists	Province/ Prefecture and DRT

CHAPTER 5. PREPARATION OF DRAFT MASTERPLAN

5.1 STARATEGY OF MASTER PLAN

Following the close examination of the existing system before the implementation of the Pilot Project in the previous chapter, a draft master plan is once formulated in this chapter, which is to be modified and improved after the implementation of the Pilot Project.

5.1.1 Necessity and Limitation of Flood Forecasting and Warning System

(1) Necessity of FFWS

The Study Area extends from the High Atlas to the Haouz Plain, covering a total of 3,500km2. There are thousands of douars scattered over the valleys, the mountain slopes and the vast alluvial fans. A total of 370,000 inhabitants are living in the Study Area, and ten thousands of tourists gather on the weekend in summer. On the other hand, innumerable douars, roads along the rivers and tourist spots are exposed to rain-induced disasters such as river flood, debris flow, landslide and slope failure due to its topographical, geological and meteorological conditions as revealed by the geo-morphological study in Section 3.1.

Basically to protect the inhabitants and the tourists from these disasters, structural measures such as flood control dams, river improvement works including dike construction and excavation of river channels, check dams should be provided. In fact some structural measures have been implemented already as discussed in Subsection 2.8.2. However, the structural works are insufficient and still far from desired safety levels, due to financial constraints.

Flood Forecasting and Warning System (FFWS) is a tool to minimize disaster damages. In particular it can contribute reduction of loss of human lives with less cost if it is properly operated. From this reason, FFWS is preferred and has been provided for many areas in the world. FFWS is required from the same reason in the Atlas Region too that experienced the 1995 catastrophic disaster.

(2) Limitation of FFWS

FFWS is effective only if it is operated properly. It is a kind of supporting measure for local inhabitants and tourists to minimize the risks. Unless local inhabitants and tourists take any action to avoid the risks, they are still exposed to the risks of disasters. Thus, it is important to understand the limitation of the FFWS as discussed below:

- FFWS is one of the non-structural measures, by which inhabitants and tourists are given flood warnings for evacuation purpose. People are adiviced to evacuate themselves to safe places. However, it depend upn the person whether he/she follow the advice. Some people can ignore the warnings and can be injured or killed by the disaster.
- FFWS is not effective for immovables like houses and buildings. Even for movables like cars, furnitures, clouthes, money, it is not so easy to carry them out to safe places in a short time.
- FFWS is not alway perfect. It can miss floods. It is possible that the rainfall area is so small that it is not detected by the rainfall stations. Troubles of equipment are also possible.
- Because of topographical and geological charateristics of this regions, all kinds of rain-induced disasters are possible. Unfortunately mechanisms of all the disasster phenomena

are not clarified yet, maily due to lack of hydrological and geological information. Therefore, a surprise disaster beyond forecasting still is possible n this region.

5.1.2 Basic Strategy for the Formulation of Master Plan

In consideration of the above situation and present flooding problem, the basic strategy to formulate the Master Plan is as follows:

(1) Identification of the Necessity and Role of the FFWS

The study area covers six (6) river basins featured with inherent flooding problems; namely, differences in causes and contents of damage. The causes include flood and debris flow, and contents include damage to inhabitants and tourists, or both. In this context, it is necessary to clarify the inherent problems, and to identify the necessity and role of the flood forecasting and warning system. The flood forecasting and warning system to be set up in this study shall meet the requirement through the identification of the necessity and role of the system for each basin.

(2) Assurance of the Reliability of the System

To mitigate the flood damage, it is necessary for people affected by flood and the agencies concerned to take proper action. In this connection, the flood information should have enough accuracy and be timely distributed to all people concerned. In this study, the flood forecasting and warning system will be set up with assurance of reliability of the system.

(3) Consideration of Sustainability of the System

Needless to say, the flood forecasting and warning system has to function well and should be maintained to provide flood information all the time, and thus, the system should also be sustainable for a long time. For that purpose, the system will be established considering the availability of engineering staff and technicians, as well as the operation and maintenance capability of the present organization involved in flood forecasting and warning.

(4) Justification of the System

In general, the scale of the project has to be justified based on the economic viability through comparison between cost and benefit. However, the flood forecasting and warning system sometimes faces the difficulty of evaluation of project benefit in monetary term, since it includes crucial intangible benefits such as relief of human lives. Therefore, the project should be justified not from economic viability but social requirement considering the intangible benefit. To justify the project scale from the social requirement, there seems to be no suitable way except referring to similar projects in the other basins.

(5) Promotion of Coordination of Agencies Concerned and Public Participation

The flood information is disseminated through many people and the evacuation to escape the flood damage is also undertaken through coordination and participation of many people. In this sense, it is essential to promote the coordination of agencies concerned, as well as public participation, for the successful operation of the flood forecasting and warning system.

(6) Full Utilization of Results of Pilot Project

In the master plan study, a pilot project will be proposed to examine the efficiency of the draft Master Plan. Then the Master Plan will be finalized considering the merits and demerits of the pilot project.

(7) Full Consideration of Related Studies

At present, several related studies are ongoing in and around the Study Area, such as the "National Flood Protection Plan", "Automation of Ouergha Basin Network", "Study and Technical Assistance for Installation of Hydrological Telemetry System for Oum Er Rbia and N'fis River basin" and the "Regional Water Resources Development Study". Since the proposals from these studies are much concerned with the consequence of the Study, these related studies will be fully considered.

5.1.3 Basic Conditions of Master Plan Formulation

In principle, the Master Plan is to be formulated taking the following conditions into consideration:

(1) Target Completion Year

The scale of the FFWS master plan may be not as large as structural measures. Like the Ouergha and Souss/Messa telemetry projects explained in Subsection 2.11.1, the master plan can be completed in 3 to 4 years or in 5 years at the maximum if the financial conditions allow.

In this Study, the target completion year of the master plan is set up in 2009, assuming that the implementation of the master plan starts in 2005 and takes 5 years for the completion as follows:

Necessary Process and Period

Necessary Process	Period (years)	Remarks
F/S and D/D	1.5	
Procurement of Equipment (Manufacturing and Shipment included)	1.5	Hydrological Equipment, Data Transmission, Data Management, etc.
Civil Construction Works and Installation of Equipment	1	Some works are implemented simultaneously with the procurement of equipment.
Experimental Operation	1	Data collection for provision of Guideline
Provision of Guideline	(1)	Guideline for Issuance of Warning, which can be prepared through the experimental operation.
Total	5	Year 2007(Starting from 2003)

(2) Target Flood

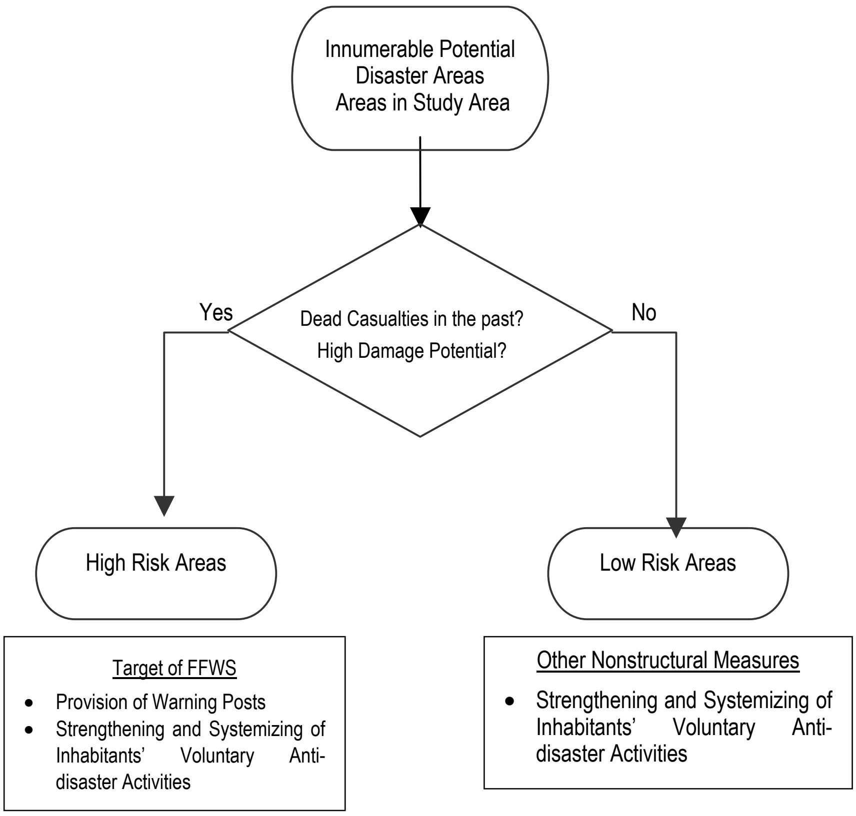
In the Atlas Region the most serious flood was the one in 1995, which started this Study in a certain sense. The FFWS master plan is to be formulated to cope with the flood conditions of the 1995 flood as the target flood. Facilities and systems are designed to meet the exceptional flood.

5.2 Selection of Target Areas for FFWS

As previously explained, innumerable douars, roads along the rivers and tourist spots are exposed to rain-induced disasters such as river flood, debris flow, landslide and slope failure due to its topographical, geological and meteorological conditions. In addition, in summer weekends some 10 thousand tourists visit the mountain valleys for seeking clean cold water. The purpose of the FFWS for this region is to evacuate those inhabitants and tourists in the potential disaster areas safely during a rain-induced disaster. However, the problem is how to deal with those potential disaster areas scattered all over the Study Area within a limited investment. In particular potential debris flow areas are found along uncountable small streams in the valleys as shown Fig. 3.1.2. It is far impossible to input a measure to every small stream. Therefore, prioritization is inevitable to maximize the benefits from the Master Plan by investing more to high risk areas.

In other words, the FFWS proposed in this Study will target such high risk areas alone. For low risk areas, other low cost or cost-free measures depending on inhabitants' voluntary activities should be conceived as discussed in Subsection 5.5.3.

The classification of high and low risk areas must be based on a comprehensive examination on damage potential and past disasters. As the FFWS aims to save human lives, dead casualties in the past disasters and expected damage potentials including loss of human lives are allowed to be main indicators for selection of high risk areas.



Conceivable Measures for Potential Disaster Areas

5.2.1 Disaster Characteristics

Prior to selection of such high risk areas, discussions in Sections 2.5, 2.7, 3.1 and 3.2 are reviewed and summarized on disaster characteristics by river basin as below (Table 5.2.1):

(1) R'dat River Basin

Although a few spots of the national road N9 and a few houses along the river are vulnerable to inundation, the R'dat River Basin is generally well protected from a river flood. The problem in this river basin is debris flow disasters as experienced in the Tazlida Tributary.

(2) Zat River Basin

The disaster situation of the Zat River is very similar to that of the R'dat River. Debris flow disasters are more serious than river floods. The riverbed and banks are utilized as agriculture areas that are sometimes affected by a river flood, but douars are generally located high enough.

(3) Ourika River Basin

The August 1995 disaster that killed some 210 people is unforgettable. This disaster was considered as a result of mutual effects between river floods and debris flows. Debris flows worsened the flood disaster. It is also noted that most of the dead causalities were tourists from all over Morocco.

The road P2017 that runs along the river is very low in several stretches. According to the hydraulic simulation in Section 3.2, a total of 6 km between Aghbalau and Setti Fadma is vulnerable to inundation. Debris flows are also threats in this valley. Many steep streams with unexhausted unstable debris on their beds are crossing the road.

On the contrary, in summer these dangerous areas attract several hundred thousands of tourists who are not familiar with such disasters. Not only the two major tourist spots, Iraghf and Setti Fadma but also other low places along the river, where a lot of tourists gather for playing with cool water, are exposed to such flood inundation and debris flows. It can be said that damage potential is still very high in spite of all the efforts made by the government after the 1995 disaster as described in Section 2.8.

(4) Rheraya River Basin

This river basin is the smallest and steepest among the six objective basins. This topographical condition generates flash river floods and debris flows.

In the 1995 disaster debris flows took place in many tributaries, one of which killed two people in Imlil. In the lower stretches river water overtopped the low roads, R203 and P2015, and five people were killed at a tourist spot, R'ha Mouley Brahim. Another people-gathering place, Asni Market, which could barely survived the 1995 flood, is also exposed to a river flood.

(5) N'fis River Basin

The N'fis River Basin is the largest among the six river basin. The river is longer and gentler than the other four mountain rivers. Damage potential by river floods seems low except for T. N. Yakoub where a considerable number of houses are located on the low river banks.

Instead, debris flows are significant in this river basin. In 1995 debris flows took place in the tributaries of Imigdal and Ourigane and brought out a lot of damages. In the douars of Tisgui and Targa, six and one persons were killed respectively in the debris flows.

(6) Issyl River Basin

The Issyl River in the Study Area is much different from the others. It flows down the flat plain named Haouz Plain. This river is totally dry in normal time but a flash flood often surprises people in the urban area of Sidi Youssef Ben Ali. Some dead casualties have been reported in the past floods such as those in 1963 and 1990.

5.2.2 Selection of High Risk Areas

Based on the above discussion, high risk areas that will be targeted for the Master Plan are selected as shown in Fig 5.3.1 and summarized as follows:

Selected High Risk Areas

Province /Prefecture	River Basin	Area	Type of Disaster	Targets to be protected	Causalities in Past Floods
Al Haouz	R'dat	Tazlida Tributary	Debris flow	Village	3 dead in '95
	Zat	Tiferent Douar	Debris flow	Village	11 dead in '95
	Ourika	Tiguemmi-n-Oumzil et Tnite	River Flood	Village	A bridge and a village is exposed.
		Aghbalau	River Flood & Debris flow	Tourists, Village	13 dead in '95, Tourist Spot
		Iraghf	River Flood & Debris flow	Tourists, Village	180 dead in '95, Tourist Spot
		Tazzitount	River Flood & Debris flow	Tourists, Village	10 dead in '95, Tourist Spot
		El Kri	River Flood & Debris flow	Tourists, Village	2 dead in '95, Tourist Spot
		Setti Fadma	River Flood & Debris flow	Tourists, Village	8 dead in '95, Tourist Spot
	Rheraya	R'ha Mouley Brahim	River Flood	Tourists, Village	5 dead in '95, Tourist Spot
		Asni Market	River Flood	Market, Shopping Custommers	Saturday Market
		Imlil	Debris Flow	Village, Tourists	2 dead in '95, Tourist Spot
	N'fis	T. N. Yakoub	River Flood	Urban Area	1 injured in '95
		Tizgui	Debris Flow	Village	6 dead in '95
		Targua	Debris Flow	Village	1 dead in '95
SYB. Ali	Issyl	Municipality of Sidi Youssef Ben Ali	River Flood	Urban Area	Many dead in '56
		Guannoune Douar	River Flood	Village	

5.3 Major Points of Improvement

Following the strategy of Master Plan in Section 5.1, this section describes major points of improvement to be attained in the Master Plan.

5.3.1 Hydrological Observation and Data Collection

As discussed in the Chapter 4, it can be said that Al Haouz Province, DPE and DMN as well as DRHT (ABHT) are now involved in hydrological observation and data collection. However, DRHT should be a primary organization for this subsystem as understood from the responsibility and technical capacity of DRHT. In this sense, this Study places a focus on improvement of the hydrological observation and data collection system of DRHT, and those of the other organizations are considered to be supplemental to the DRHT system.

(1) Improvement of Flood Watch Station Network

There are generally two directions towards improvement of the present flood watch system. The first one is extension of the covering area, which will be attained by adding flood watch stations. The second one is modernization of equipment including automation by introduction of a telemetry system.

(a) Installation of New Stations

Installation of new stations is essential to minimize blind areas. They can bring more flood information and lead to enhancement of reliability of the system. However, the more stations, the costlier the Master Plan will be. The number of the new stations should be limited at the minimum, considering hydrological requirements and locations of the selected high risk areas. Therefore, the following criteria is proposed to establish a deployment plan of rainfall and water level stations:

(i) Criteria for Rainfall Station

- At least a station must be installed upstream of every high risk area,
- For the Ourika River Basin of which damage potential is the highest among the six basins, a station is to be given to every major tributary,
- A rainfall gauge is to be installed at the Oukaimeden relay station to measure rainfall at a high altitude of 3,273m, and
- To avoid robbery of equipment and to ease maintenance works, rainfall stations must be located in or near douars in principle.

(ii) Criteria for Water Level Station

- At least a water level station must be installed upstream of every high risk area for a river flood,
- A new water level station must be installed at least 10 km upstream from the corresponding high priority area to ensure minimum lead time of 45 minutes (4m/s of flood propagation velocity is assumed). This 45-minute lead time allows a margin of 15 minutes for necessary consecutive actions from observation and data collection to evacuation that need 30 minutes under the master plan condition proposed in Subsection 5.4.4.
- To avoid robbery of equipment and to ease maintenance works, rainfall stations must be located in or near douars in principle.

Based on the above criteria, a deployment plan comprised of 8 existing and 12 new stations is tentatively proposed as below (refer to Fig 5.3.1 and Table 5.3.1):

Deployment Plan of Flood Watch Stations

River Basin	Number of Rainfall Station			Number of Water Level Station		
	Existing	New	Total	Existing	New	Total
R'dat	0	1*	1*	0	0	0
Zat	0	1*	1*	0	0	0
Ourika	6 (5)	5** (1)	11** (6)	5 (5)	1 (1)	6 (6)
Rheraya	1 (1)	2** (1)	2** (2)	1 (1)	1 (1)	2 (2)
N'fis	1 (1)	3 (2)	4 (3)	1 (1)	2 (2)	3 (3)
Issyl	0	2 (1)	2 (1)	0	1 (1)	1 (1)
Total	8 (7)	12 (5)	20 (12)	7 (7)	5 (5)	12 (12)

Note: Number in parentheses is number of stations equipped with both rainfall and water level gauges.
* : The Gdrar Guedronz Station is located on the boundary of the R'dat and Zat River Basins, and counted for the two basins.
**: The Oukaimeden Station is located on the boundary of the Ourika and Rheraya River Basins, and counted for the two basins.

(b) Modernization of Equipment

As discussed in Section 2.11, DGH is eagerly promoting automation of hydrological observation and data collection for management of flood and water resources as seen in the projects of the Ouergha River Basin, the Oum Er Rbia and N'fis River Basin, and the Mediterranean Coast Area. Modernization of hydrological observation networks is one of the major targets of the five-year action plan of DGH.

However, it is true that a big gap is still existing between the present manual system and the fully automatic system in terms of technology and cost. The present manual system has commenced in the Ourika River Basin just a few years before, and it seems to be very early to introduce a new system. As long as sustainability of the new system is not ensured, such automation might be hesitated. In this regard, three options from the existing manual system to a fully automatic system are conceived and compared for determining the development level of the hydrological observation and data collection subsystem in Section 5.4.

(2) Information Collection from Related Organizations

DMN, DPE, AL Haouz Province and DREF have their own observation networks, telecommunication measures and/or technology and equipment for data analyses. These organizations could provide to DRHT useful information on weather, rainfall, river condition and disasters that helps DRHT forecast a river flood and debris flow very much. In this master plan study, inter-organization collaboration with these organizations is discussed to maximize utilization of information available among them, taking into account institutional arrangement. It is also noted that these collaborations must be made in a reciprocal manner.

Information from Related Organization

Organization	Possible Information
DMN	Weather Forecast, Alert Message, (Satellite Pictures and Radar Pictures)
DPE	Weather Condition, River Condition and Disaster Areas
Al Haouz Province	(Weather Condition , Rainfall and Disaster areas)
DREF	(Weather Condition, Rainfall)

Items in parenthesis are information that is now not given to DRHT

(a) Collaboration with DMN

DMN is an only organization that is responsible for weather forecasting in the kingdom. The organization has many technical staff, sophisticated equipment and software, and information from this organization is very precious for the FFWS in the Study Area too. In this context, collaboration with DMN should be strengthened to collect more information including radar pictures and satellite pictures. In return DRHT can provide their real-time hydrological data that must be valuable to DMN too.

(i) Recommendation of Installation of Precipitation Radar near Marrakech

A precipitation radar is a strong tool to grasp spatial movement of rainfall areas. This information helps the flood forecaster of DRHT very much to forecast future rainfall condition whether rain will be stopped, increased, decreased, etc. Moreover, after point rainfall data at the flood watch stations and radar information will have been accumulated to some extent in future, elaboration of a model for estimating rainfall intensities over an wide area will be possible.

As described in Subsection 2.8.1, DMN has a plan to install a new precipitation radar in Marrakech or Oujda (Northeast Morocco), in 2001 at the earliest. To enhance accuracy of weather forecast and alert messages in the Study Area, it is strongly recommended that the radar be installed near Marrakech. With this radar, the blind area of the existing radar network will be eliminated greatly especially for the High Atlas. It is also recommended that the radar information be transmitted to DRHT.

On the other hand, it can be considered that DGH should install a precipitation radar to cover the High Atlas at Marrakech by themselves. However, this idea seems to be unrealistic from the reasons below:

- The proposed flood forecasting model does not require radar information directly, which is useful for rainfall forecasting,
- Radar pictures and DMN's interpretations seem to be sufficient for the flood forecasting purpose,
- A radar is too costly if it is used only for flood forecasting, and
- Such a radar can be fully utilized only by DMN who has enough experience on radar operation.

(ii) Satellite Pictures

Besides radar pictures, satellite pictures are also very useful. If they are given to DRHT in addition to radar pictures, DRHT that now can know only point rainfalls with its flood watch network alone will be able to grasp movement of clouds over the kingdom. This helps DRHT to conduct flood forecasting more precisely.

(b) Information from Other Organizations

Brigade posts of DPE, Caidat offices of the province/prefecture and forest posts of DREF can possibly play a role of flood watch station. In addition, warning posts that are proposed to be newly installed in the high risk areas in this Study also are to communicate with the province/prefecture information on weather, rainfall and damages, etc. They are all equipped with a VHF radiotelephone, and DREF posts and some of Caidat offices have a storage type rainfall gauge too.

As for DPE who has a close relation with DRHT under the same ministry, DRHT should continue to exchange data/information each other even during a flood as described in the MOE Guideline. The province/prefecture that is closely related to inhabitants is also an important source of flood information. In particular, live information from warning posts that will be available via the prefecture/province is very precious for flood forecasting of DRHT. DRHT must keep in contact with the prefecture/province for such information.

However, it is very hard to expect as much from DREF, as from the flood watch stations of DRHT because DREF is not given any responsibility for the FFWS. It is risky to depend on this forestry organization too much in emergency. Therefore, DRHT need not to bother to collect rainfall data from DREF during a flood. Instead, Its rainfall data must be used in normal times for improvement of flood forecasting models. If necessary, a kind of convention as the existing one between DMN and MCEF should be made between DGH and them.

5.3.2 Data Analysis and Forecasting

According to the ME guideline, DRHT is to make hydraulic and hydrological analyses to interpret rainfall and water level data, and then to distribute flood information/notices to related organizations. This subsystem of the present FFWS still remains very far from a satisfactory level, and no scientific analysis other than conversion from water level to discharge has been done. Thus, upgrading of this subsystem is of first priority.

(1) Data Analysis

Data analysis includes the following functions:

- Data processing,
- Data storage, and
- Visualization of processed data

(a) Data Processing

Rainfall data are automatically processed into accumulated rainfalls, rainfall intensities and basin mean rainfalls, and water level data are also automatically converted to discharges based on the Mannings' Formula.

Data to be Collected from Flood Watch Station

Data	No. of Data	Collection Frequency	Information
Rainfall	20	Usually, the data collection interval is every hour. The interval can be changed to every 10 or 30 minutes.	• Time of observation: year, month, day, hour, minute. • Total rainfall from the previous observation.
Water Level	12	Usually, the data collection interval is every hour. The interval can be changed to every 10 or 30 minutes.	• Time of observation: year, month, day, hour, minute. • Total rainfall from the previous observation.

(b) Data Storage

The processed data are automatically stored in a database together with the measurement time. The database is renewed every time new data are collected from the stations.

(c) Visualization of Processed Data

The processed data are automatically visualized in a variety of maps, graphs and tables as shown in Fig 5.3.2 and summarized below:

Presentation of Processed Data

No	Item	Information Included
1	Flood Status Map	Rainfall intensities and water levels are classified into a few status according to their magnitude.
2	Flood Status Diagram	Current rainfall intensities and discharges on the schematic diagram of Ourika River.
3	Rainfall Graph (All Stations)	Rainfall at all the rainfall stations for last 24 hours.
4	Rainfall Graph (Each Station)	Rainfall at each rainfall station for last 24 hours.
5	Discharge Graph (All Stations)	Discharges at all the water level stations for last 24 hours.
6	Discharge Graph (Each Station)	Discharge, water level and basin mean rainfall at each water level station.
7	Rainfall Table	Rainfall intensity and accumulated rainfall in last 24 hours.
8	Water Level and Discharge Table	Water Level and discharge in last 24 hours

In these maps and graphs, the processed rainfalls and discharges are compared with two alert levels to categorize seriousness of the flood in terms of magnitude of rainfall and discharge as described in (3) Flood Notices of this subsection. The two levels are Pre-alert and Alert rainfalls/discharges that are used for determination of announcement of the flood notices.

(2) Forecasting

First of all it is stressed that forecasting of flood and debris flow for the objective river basins is very hard. Rainfall is so intensive in space and time, and phenomena is so fast. Available data is also very scarce.

Under these difficulties, a forecasting model is proposed in this Study for river floods and debris flows respectively. However, it is dangerous to rely on the forecasting models too much. Care must be taken to interpret forecasted results, and updating of these models should be done after every flood and debris flow to make them more reliable. It is recommended that actual observed data not forecasted results be used for decision-making such as announcement of flood notices as long as these models can not give sufficient accuracy.

(a) Flood Forecasting

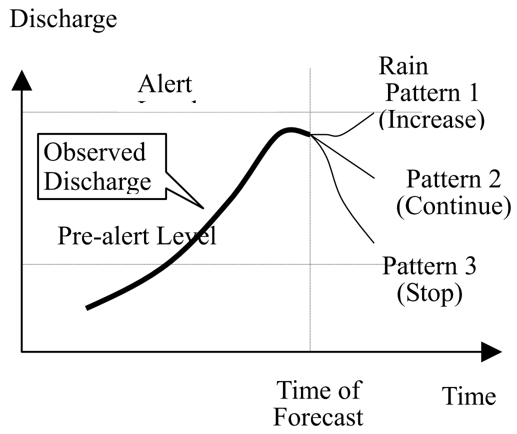
As discussed in Subsection 4.2.2, two simple models were elaborated after the 1995 disaster by a local consultant, INGEMA. These models have never been applied for an actual flood, probably because they are still premature for the practical forecasting. The both models are not real-time models, and can not utilize rainfall and discharge information successively brought by flood watch stations.

As a challenge to solve the problems, a real-time forecasting model is proposed in this Study. The model is basically composed of runoff analysis for sub-basins and flood routing in rivers. USSCS model and the Muskingum Method that were used for elaboration of the deterministic model by INGEMA are used respectively for the runoff analysis and flood routing. The proposed model has been verified for the Ourika River Basin in Section 3.2, by using data of the October 1999 flood. Main features of the proposed model is as follows:

Main Features of Proposed Model

Item		Description
Objective Rivers		Ourika, Rheraya, N'fis and Issyl Rivers
Forecasting Period		3 hours at the maximum
Model	Runoff from Sub-basin	USSCS Method
	Flood Routing	Muskingum Method
Input Data	Observed Data (Automatically)	Rainfall Intensity, Discharge
	Future Rainfall	Selection of Future Rainfall Pattern
Output		Discharges of every 10 minutes

The proposed flood forecasting system enables real-time forecasting. Every time new hydrological data are obtained, calculation can be made and flood forecasts are updated. The consecutive procedure from data reading to calculation and presentation of results is automatically made except for selection of future rainfall pattern. The objective river basins are so small and steep that the concentration time is as short as 2 to 3 hours. Thus rain forecast is required to forecast discharge in future, and three patterns of future rainfall are incorporated in the flood forecasting system.



Result of Flood Forecasting

(b) Debris Flow Forecasting

Forecasting of debris flow is more difficult. The phenomena are so complicated that a practical physical forecasting model has not been established yet. Under these circumstances, two ways are conceivable. The first one is directly to detect a debris flow in the upstream by a debris flow sensor. The second one is to use rainfall as a indictor of debris flow.

(i) Debris Flow Sensor

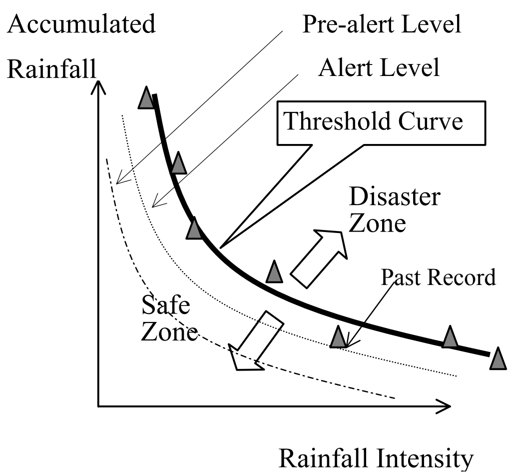
Three types of sensors are available and have been applied in the world. They are a wire sensor, an acoustic sensor and a vibration sensor. The wire sensor is very simple. A wire is stretched across a debris flow potential stream so that it can be cut by flowing debris. The acoustic sensor and the vibration sensor are installed on the bank to detect sounds or vibration caused by a debris flow. Since these sensors need telecommunication equipment to transmit a signal to the downstream, they are very expensive. Even a set of the wire sensor costs more than several hundred thousands dirhams.

Another problem is that too very short lead time is left available even if village people are directly informed of a debris flow by such sensor. According to a research on debris flow in Japan, the speed of debris flows can reach 10 m/sec. Generally streams in the Study Area that contain a risk of debris flows are steep and short. If the distance from the sensor to the downstream village is 2 km, the debris flow reaches the village in only 3 or 4 minutes. The debris flow comes down too fast for the village people to escape safely in time.

Considering the above, debris flow sensors seems to be not practical in the Study Area. The second way is more realistic as discussed below:

(ii) Threshold Curve

This method is to ensure more lead time for evacuation by issuing a warning before outbreak of a debris flow. Rainfall data is used as a indicator of the debris flow risk. In this method a warning is issued when rainfall is expected to reach a certain level near a threshold line that has been drawn based on past debris flow records. This method can give some more time than debris sensors although the accuracy is lower.



Relation between Rainfall and Occurrence of Debris flow

To enhance the accuracy, a close analysis on past debris flows is indispensable. Relations between accumulated rainfall and rainfall intensity just when debris flows took place must be investigated to draw a threshold curve as shown in the right figure.

Unfortunately, there are not available data enough to create an original threshold curve for the Study Area. Therefore, a threshold curve developed in Japan for an area that is geologically and topographically similar to the Study Area is proposed provisionally. After accumulation of necessary data, the curve must be updated.

(3) Flood Notice

In addition to the processed flood information, DRHT (ABHT) is supposed to distribute flood notices in the MOE Guideline for flood management. This Study proposes definition of the flood notices that has not been clearly described in the guideline, considering characteristics of disasters in the Study Area.

(a) Definition of Flood Notices

Flood Notices are messages on flood situation announced by DRHT to call for necessary actions of related organizations against probable river flood and/or debris flow disasters. Three kinds of Flood Notices are defined for each of river flood and debris flow. These Notices are announced for each warning post area independently. They are Pre-River Flood/Debris Flow Notice, River Flood/Debris Flow Notice, Cancellation of River Flood/Debris Flow Notice(s), as defined below.

Flood Notices

Type of Disaster	Flood Notice	Definition
River Flood	Pre-River Flood Notice	This notice is to notify related organizations that rainfall and/or discharge has exceeded the Pre-Alert Level and situation is expected to further worsen.
	River Flood Notice	This notice is to notify related organization that rainfall and/or discharge has exceeded the Alert Level and situation is expected to further worsen.
	Cancellation of River Flood Notice(s)	This notice is to notify related organizations that rainfall and/or discharge has decreased below the Pre-Alert Level and the situation has became normal.
Debris Flow	Pre-Debris Flow Notice	This notice is to notify related organizations that rainfall has exceeded the Pre-Alert Level and situation is expected to further worsen.
	Debris Flow Notice	This notice is to notify related organizations that rainfall has exceeded the Alert Level and situation is expected to further worsen.
	Cancellation of Debris Flow Notice(s)	This notice is to notify related organizations that rainfall has decreased below the Pre-Alert Level and the situation has became normal.

(b) Definition of Alert Rainfall/Discharges

These Notices are announced according to seriousness of the flood situation that is evaluated from rainfall or water level at reference stations designated for each warning post area out of the 20 flood watch stations. Pre-Alert Level and Alert Level of water level and rainfall that are regarded as indicators for the seriousness are defined as below:

Pre-alert and Alert Rainfall/Discharge

Alert Level	Consideration for Determination of Values
Pre-alert rainfall/discharge	The minimum level that needs preparedness for evacuation.
Alert rainfall/discharge	The minimum level that needs immediate evacuation.

(4) Distribution of Flood Information/Notice

Processed flood information and flood notice is basically distributed to related organizations as follows:

Flood Information/Notices Distribution

Information/Notice	Recipient
Processed Flood Information	DGH, DPE, ONEP, ONE, ORMVAH, (Al Haouz Province ant its Cercles and Caidats, and Sidi Youssef Ben Ali Prefecture and its Cercles and Caidats)
Flood Notices	

Organizations in parentheses are not included in the routes in Fig 4.3.6.

Processed flood information as shown in Fig 5.3.2 is very helpful to understand the flood notices for the related organizations. Shearing of the same information among these execution organizations contributes to more effective interventions against a flood disaster. The reason why the flood information is given directly to local authorities (province/prefecture, caidat offices) not via DPE, is that utilization of a computer network is considered as a communication measure to ensure prompt and accurate transmission of enormous graphic data as discussed in Subsection 5.4.2. The governor of the province/prefecture is to issue flood warnings mainly based on the Flood Notices.

Regarding the configuration of the information distribution system, three options are compared in Subsection 5.4.2.

5.3.3 Flood Warning Issuance

The governor of the province/prefecture is responsible for issuance of warnings for inhabitants and tourists in his jurisdiction. The governor finally presses a button of flood warnings for evacuation, based on collected information including the flood notices from DRHT (ABHT). To assist the governor to decide the issuance of warnings promptly, a guideline is proposed in this Study.

(1) Definition of Flood Warnings

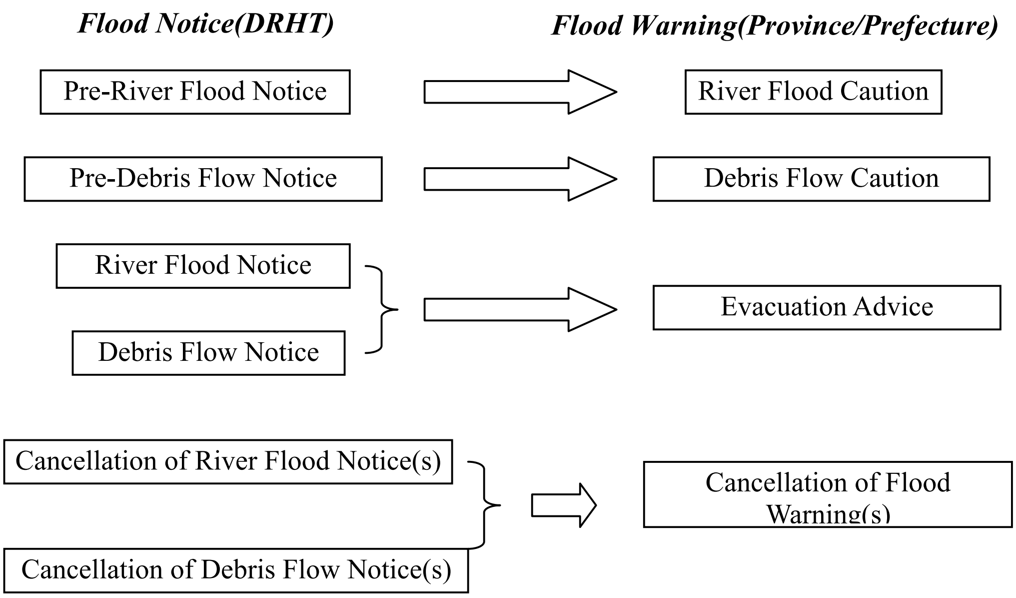
Four kinds of Flood Warnings, River Flood Caution, Debris Flow Caution, Evacuation Advice, Cancellation of Flood Warning(s) are defined as follows:

Definition of Flood Warnings

Flood Warning	Definition
River Flood Caution	This warning is to warn personnel of related organizations, inhabitants and tourists that a flood is expected.
Debris Flow Caution	This warning is to warn personnel of related organizations, inhabitants and tourists that debris flows are expected.
Evacuation Advice	This warning is to advice inhabitants and tourists to evacuate to designated places immediately.
Cancellation of Flood Warning(s)	This warning is to notice personnel of related organizations, inhabitants and tourists that the flood warning(s) has/have been cancelled.

(2) Issuance of Flood Warnings

To judge the issuance of the warnings, technical information is indispensable. In addition, the judgment must be made appropriately and promptly even when the governor is absent. In this context, the flood notices announced by DRHT should be referred and connected to the flood warnings as follows:



Relation between Flood Notices and Warnings

With the above relation, the governor is able to decide the issuance of the Flood Warnings promptly based on the Flood Notices. For example: upon receiving a River Flood Notice, the governor can issue Evacuation Advice for a relevant high risk area immediately. Nevertheless, the Flood Notices are not directions from DRHT to the governor. It is of course that the final decision whether to issue Flood Warnings or not is made by the governor. The notices are a kind of technical advice from DRHT, and the governor is still responsible for the warning issuance.

5.3.4 Flood Warning Dissemination

Flood warnings must be promptly and precisely disseminated to inhabitants and tourists in dangerous areas. At the same time, the warnings shall be diffused to related organizations that might be involved in relief activities.

(1) Recipients of Flood Warnings

In addition to inhabitants and tourists in dangerous areas, the following organizations are conceived as recipients of flood warnings:

Recipients of Flood Warning

Classification	Communication Measure	Recipients
Warning Post	Warning Broadcasting System	Inhabitants and tourists
Local Authorities	Telephone, Fax, VHF Radiotelephone	Relevant Cercles, Caidats
Other Related Government Organization	Telephone, Fax	Royal Mounted Police, Civil Protection, Ministry of Interior, and other organizations involved in ORSEC Plan
Broadcasting Mass Media	Telephone, Fax	Mass Media (TV and Radio)
Tourism Related Industries (hotels, restaurants, etc.)	Telephone, Fax	Managers and Employees, then Tourists

Mass media such as TV and radio is very effective to diffuse information to numerous individuals at a same time. Unfortunately the mass media is now not involved at all in the dissemination of warnings including alert messages by DMN. According to the JICA Electrification Study, the diffusion rate of TV and radio sets are unexpectedly high, 0.57 and 1.21 sets/household respectively even in the mountainous areas of Al Haouz Province where a telecommunication measure is hardly available. It is strongly suggested that the mass media be involved in the warning dissemination.

(2) Installation of Warning Posts

As repeatedly pointed out, the problem is the lacking of telecommunication measures for the most important recipients, namely inhabitants and tourists whom a disaster is threatening. An appropriate communication measure including a voice amplifier with a loudspeaker (Warning Post) to diffuse a warning to inhabitants and tourists must be introduced to the selected high risk areas as shown in Fig. 5.3.3. Three options of the warning dissemination system are conceived and compared in Subsection 5.4.3.

5.3.5 Evacuation

To facilitate execution of safe and prompt evacuation, an evacuation plan must be prepared for every warning post area. In this Study a guideline for preparing the evacuation plan is proposed, and an evacuation plan will be elaborated for the Pilot Project Area in accordance with the guideline in the second field survey period.

Generally an evacuation plan must include the following element.

- Evacuation Organization
- Operation of Warning Post

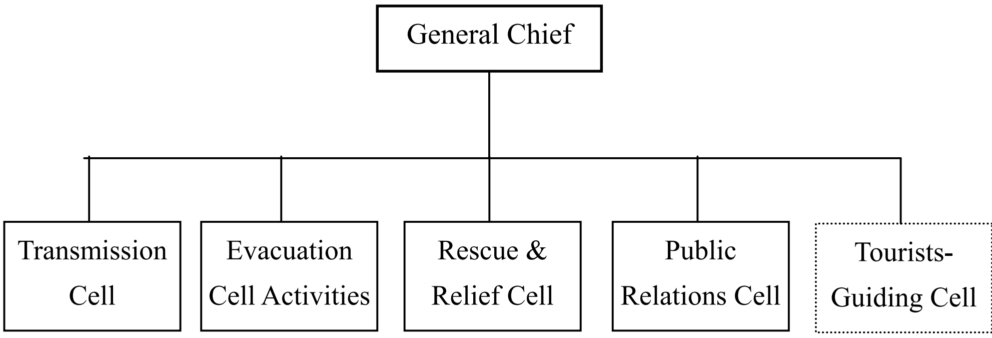
- Evacuation Places and Routes
- Stock of Materials and Equipment
- Diffusion of Warning Messages
- Guidance of Evacuees
- Guidance of Tourists
- Evacuation Drill
- Public Relations
- Evaluation of Evacuation Activities and Updating of Evacuation Plan

(1) Set-up of Evacuation Organization

An evacuation organization must be formed among inhabitants for every warning post area that includes a douar or more. The evacuation organization is responsible for all activities related to evacuation under the guidance of the Province/Prefecture.

The evacuation organization may be generally composed of five cells under a general chief who supervises all the cells. In tourist spots, a cell for guidance of tourists should be added to the evacuation organization.

Each cell is composed of a cell chief and some members who are selected among inhabitants in consultation of the relevant caidat and/or Province/Prefecture. However, a chief and members of the tourists-guiding cell are selected among employers and employees of tourism industries such as hotels and restaurants. Responsibilities of each cell section are given in the following table:



Organization Structure of Evacuation Organization

Members of Evacuation Organization

Cell	Main Responsibilities
General Chief	Representing the evacuation organization and supervising all cells.
Transmission	Operation and maintenance of the warning post.
Evacuation	Guiding inhabitants to designated evacuation places.
Rescue & Relief	Rescue and relief activities
Public Relations	Public .Relations on FFWS
Tourists-guiding	Guiding tourists to designated evacuation places.

(2) Guidelines of Evacuation Activities

(a) Operation of Warning Post

Equipment of the warning post, which is provided by the Province/Prefecture to the evacuation organization must be maintained and operated by the transmission cell under the guidance of the Province/Prefecture. Radio and broadcasting equipment is desirable to be installed in a busy public establishment such as school and mosque located in flood and debris disaster-free areas for preventing thefts and vandalism. Loudspeakers must be placed in such a high place that warning messages can reach all river flood and debris flow prone areas.

As described in Chapter 3, the warning post must be 24 hours on duty against a sudden development of a river flood and/or a debris flow even during the Normal Phase. At least one of the members must stay near the post at any time so as to receive a sudden call from the Province/Prefecture. Some incentives must be considered to encourage them to be engaged in the duty.

(b) Designation of Evacuation Places and Routes

Evacuation places and routes must be designated in the neighborhoods. Distances and capacities of places and risks of secondary disasters must be carefully examined in consultation with the Province/Prefecture and DPE. Some signboards showing the designated evacuation places and routes also shall be placed to installed in the douar(s) to keep inhabitants reminded of them.

(c) Stock of Material and Equipment

Materials and equipment necessary for evacuation, rescue and relief activities including shovels, ropes, torches, blankets, knives, radio sets, medicines, foods, etc. are recommended to be stocked in every household and/or public places.

(d) Diffusion of Warning Messages

Live or recorded warning messages are send over the river flood and/or debris flow prone areas from laud speakers, but it is also necessary to confirm if all the inhabitants of these places have received and understood the messages. Namely man to man oral dissemination of warning messages is still indispensable. To ensure the smooth oral communication, a communication route network among the inhabitants shall be drawn in advance.

(e) Guidance of Evacuees

The evacuation cell is responsible for smooth execution of evacuation, and they must guide inhabitants to designated evacuation places. Infants, elderly and physically handicapped people should be evacuated first. The rescue and relief is responsible for rescue and relief activities of injured people.

(f) Guidance of Tourists

As for tourist spots such as Iraghf and Setti Fadma along the Ourika River, a tourists-guiding cell shall be formed among employers and employees of hotels, restaurants, shops, etc. The cell must guide tourists who are not familiar with disasters in the places to designated evacuation places promptly and safely.

(g) Evacuation Drill

An evacuation drill must be conducted once a year at least as well as a joint communication drill with the Province/Prefecture.

(h) Public Relations

Efforts to publicize the FFWS among inhabitants and tourists shall be made continuously. Signboards explaining the FFWS and past disasters are very effective for this purpose. An evacuation drill is also a good opportunity for inhabitants to understand the system and to be reminded of past dreadful disasters.

(i) Evaluation of Evacuation Activities and Updating of Evacuation Plan

After every flood that reached the Preparatory Phase or further and every drill, all members of the evacuation organization should meet to evaluate the actual activities and drill for updating the Evacuation Plan.

5.3.6 Institutional Plan

(1) Issues

(a) Directives

Current directives prevailed in Morocco on flood forecast, warning, evacuation and relief activities, i.e., MOE Guideline and the directive for ORSEC Plan well cover most of essential elements required for organizing and managing flood fighting activities. Compared to the corresponding legislation of Japan, however, there might be some missing elements to be regulated and enforced.

In Japan, there are two important laws related to flood combating activities, namely, "Flood Fighting Act (Law No. 193 of 1949, and amended partially more than 15 times up to the present)" and "Basic Act on Disaster Countermeasures (Law No. 223 of 1961)". The former act gives provisions on i) an objective and definitions, ii) flood fighting organizations, iii) flood fighting activities, including river watch, flood alert and warning, iv) management of flood fighting activities, v) cost allocation and subsidies, vi) miscellaneous provisions, and vii) penalties. The latter basic act gives, i) general provisions – an objective, definitions, and responsibilities, ii) organizations for disaster countermeasures and their relations, iii) disaster countermeasure plans (planning items, planning entities, etc.), iv) disaster prevention (preparation of organizations, stock of materials, education and training, exercises, etc.), v) emergent activities against disasters (information collection and communication, alert and warning, evacuation, traffic control, use of materials and equipment, compensation, etc.), vi) restoration, vii) financing, viii) declaration of emergency conditions, ix) miscellaneous provisions. The basic act stipulates that there shall be no contradiction between the two acts.

Besides, in Morocco the ME Guideline deals with the procedure for issuance of flood forecast and alert and some activities related on traffic control and emergent road restoration which belong to jurisdiction of the Ministry of Equipment, because of the guideline's nature of internal circulation only. The directive for ORSEC Plan covers wide areas, emphasizing on relief activities. The latter directive deals with thorough operations of large scale, involving many sectors of the government and the private entities, and thus some parts are not suitable to flash floods, which requires forecasting and prompt countermeasures.

One of the most important elements in anti-flood activities, i.e. exercises (drills) and training, is missing in the both directives, while large scale of exercises are implemented every year in most of the flood-prone areas in Japan to enhance preparedness for flood countermeasures.

There might be some problems in enforcement and implementation of the two directives. The 2000 version of the ME guideline, which should be revised every year in May and June, is not available at the moment and specific documentation under the guideline for Province of Al Haouz, Prefecture of Sidi Youssef Ben Ali or Marrakech Menara seems not be prepared.

Although there should be evaluation reports on anti-floods activities according to the two directives, those on 1995 or 1999 floods are not available, and no feedback is documented for preparation of the new plans against floods. A basic principle of management cycle; "to plan – implement – monitor & evaluate – revise – implement - …." seems not to be explicitly applied in the management of anti-flood activities.

Currently mass media, such as radio or TV broadcasting, in alert and warning dissemination are not fully employed, probably because of limited channel, coverage or usage of the media in rural areas. Corresponding to progress of electrification and expansion of the broadcasting as well as gradual change in living styles of the people, importance of those media will grow in the future.

(b) Capacities of the Relevant Organizations

DRHT, specialized in hydro-climatological analysis and technical advisory, seems to lack mobilization capability for information collection and activities after issuance of flood forecast and alert messages. Besides, DPE –(Al Haouz and Marrakech Wilaya, covering Prefectures of Sidi Youssef Ben Ali, Marrakech Menara, Marrakech Medina and Chichaoua Province) seems not to have sufficient analytical capabilities for flood forecasting, and their jurisdiction extends not in basin-wise but only to a province, or a province and prefectures. As stipulated in the Water Act, a river agency will be created whose duties will include hydro-climatological measurement and flood fighting infrastructure arrangement. In case of the river basin of Oum Er-Rbia, the only model of the establishment, provincial water services remain, taking the responsibilities of maintenance of hydraulic works. The capability and staffing of the river basin agency to be established for the Tensift River is not yet known at the moment. The Province does not have sufficient technical capabilities for hydrological analysis and flood forecasting although it has an authority for warning and evacuation instruction, and extension capabilities.

Under the current conditions, the three organizations, as core agencies, should coordinate for flood forecasting, warning, and emergent activities, such as guiding evacuation of the residents and tourists of the flooding areas, equipped with communication.

(2) Principles

(a) Objectives

The objectives of the institutional plan are set as follows based on the strategy set for the formulation of the Master Plan:

- to enable accurate and timely forecast with close cooperation of relevant entities
- to enhance preparedness for timely and effective warning and evacuation

(b) Approaches

To achieve the above objectives the following approaches should be adopted based on the assessment of the current conditions.

(i) Inter-ministerial Involvement with Clear Assignment to Each of the Relevant Entities

For reliable and prompt issuance and dissemination of flood forecast and warning messages, as well as instructions for evacuation, close information exchange and cooperation for warning dissemination and evacuation are inevitable under the current situation or even in some period after the establishment of a river basin agency in the Tensift River Basin. For effective and efficient information exchange and cooperation in emergency situations, it is a prerequisite to prescribe clear assignment and procedure as well as to prepare formats used in the communication. Inter-ministerial preparation should be carried out. Joint evaluation will help further improvement of anti-flood activities.

(ii) Enhancing Preparedness

Rapid and effective activities in catastrophic conditions can be attained only with enhanced preparedness. Although some troubles can not be avoidable even with enhanced preparedness, well-organized preparation is the only way to reduce happening of troubles and problems in emergency situations.

(iii) Residents Participation

Normally, to let people obey the rules or instructions decided by other persons is difficult. Instead, people are better willing to follow the rules or plans which are determined by themselves. At least, taking their opinions into consideration will encourage the obedience of the people. Participation of the people with their local knowledge will contribute much to more effective and efficient plans and rules.

(iv) Applying Management Cycle

Any types of modern management employ the process of “plan – do – see – plan - ….” or “plan – do – check – action – plan - ….”. This management is also applied in the two acts related to anti-flood activities in Japan. Explicit application of the method would help grade up of the management level.

(3) Conceptual Plans

(a) Preparation of an Operational Guideline for Flood Fighting

Preparation of a guideline suitable to characteristics of the floods in Study Area, especially for flash floods, as well as applicable and effective in the social conditions of the area and capacities or capabilities of the relevant organizations, would be recommended in the Master Plan. Outline would be prepared with counterparts through discussions of relevant organizations, based on the current ME Guideline and the directive for ORSEC Plan, and referring corresponding laws, regulations and actual plans enforced in Japan. Participation of the stakeholders should be encouraged in detail planning, especially planning of evacuation or warning to tourists. Required procedure to encourage the participation should be analyzed.

After careful discussions and checks with exercises, as recommended below, legal status of the directives or plan should be raised up to regulations or decisions of the Governor for smooth and enforced implementation.

(b) Explanations and Exercises to Enhance Preparedness against Flood

Preparation against floods should start with documentation as described in the two directives prevailed in Morocco. Additional documentation as stipulated in the laws and regulations in Japan, if it is necessary and applicable in the Study Area, would be recommended with suitable formats.

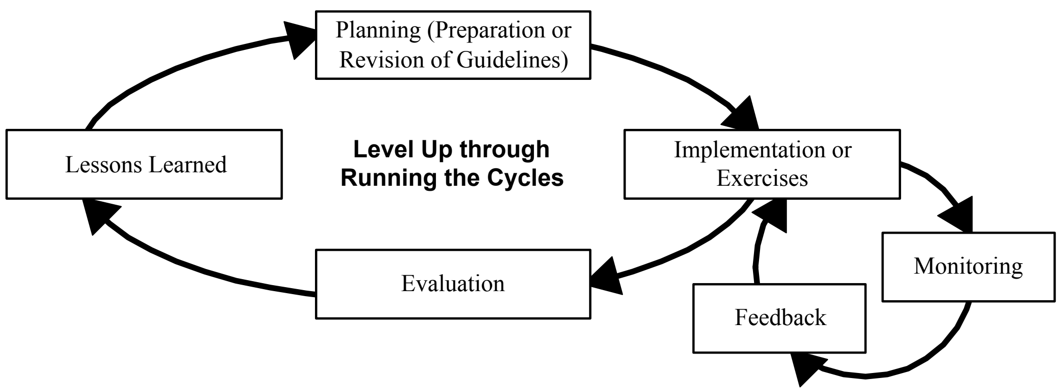
Contents of some parts of the documents as well as the plans and messages, should carefully and repeatedly be explained to relevant organizations and residents before the occurrence of the floods in order to avoid misinterpretations, which often occur in extraordinary conditions.

Exercises are often carried out in Japan in almost all flood prone areas as stipulated in the laws and regulations as obligations. Exercises, comprising of desktop drills and in situ exercises, would help to check the functions of equipment and operations and to detect mal-functions of them before the occurrence of the disasters. The results of exercises should be evaluated and reported for further improvement. Typical models of the exercises conducted in Japan would be introduced in the Master Plan.

Mass media have large potential for dissemination of forecast, alert and warning messages and for education on disaster prevention. However, careful design of messages with plain language is necessary to avoid misunderstanding of the people. Despite the possible misinterpretations, diffusion of risk information should be stated to exploit the huge potential of the media. Explanations and discussions with relevant entities should start for preparation. Model of usage of mass media would be introduced.

(c) Running Management Cycle

Everyone may know the merits of the application of management cycles and still there are many places and fields yet to adopt this approach. Examples of successful running of management cycle in the anti-flood activities would be introduced. Problems which hinder proceeding the cycle should be identified. Countermeasures to solve the problems and to promote grading up of the management would be recommended.



Management Cycle

(d) Organizational Strengthening and Training

Organizational strengthening and staff training required for reliable and prompt operation of the proposed FFWS would be recommended. After study of required personnel and skills to manage the proposed system, necessary staff increases and contents of training would be recommended.

5.4 Conceivable Equipment Options

As described in Section 5.3, conceivable equipment options for each of the hydrological observation and data collection subsystem, the data analysis, forecasting and distribution subsystem and the warning dissemination subsystem are discussed in this chapter.

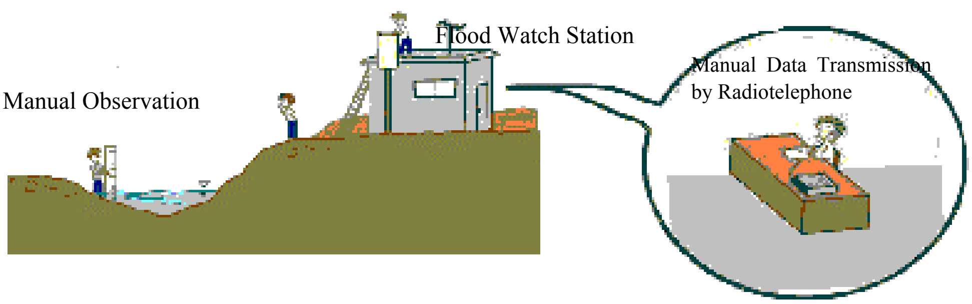
Three different development levels are basically considered: namely Option-A is a manual system, Option-B is a semi-automatic system and Option-C is a fully automatic system. For each of the three subsystems of the proposed FFWS, three options of different development level are conceived as follows:

5.4.1 Three Options for Hydrological Observation and Data Collection

(1) Option-A

This option is a kind of spatial expansion of the existing manual system. No upgrading of the facilities is made but the blind areas of hydrological observation network can be reduced with the new stations.

This option follows the existing manual operation. Conventional hydrological sensors such as a storage type rainfall gauge and a staff gauge type water level gauge are installed at the new stations to expand the coverage areas. The new flood watch stations are equipped with a new VHF radiotelephone unit too. A HF/SSB radiotelephone is also provided for all the stations as a backup of the VHF radio network.



Manual System

(2) Option-B

This is a semi-automatic system. Equipment for observation is upgraded to automatic one but that for data collection is the same as Option-A.

(a) Automatic Sensors

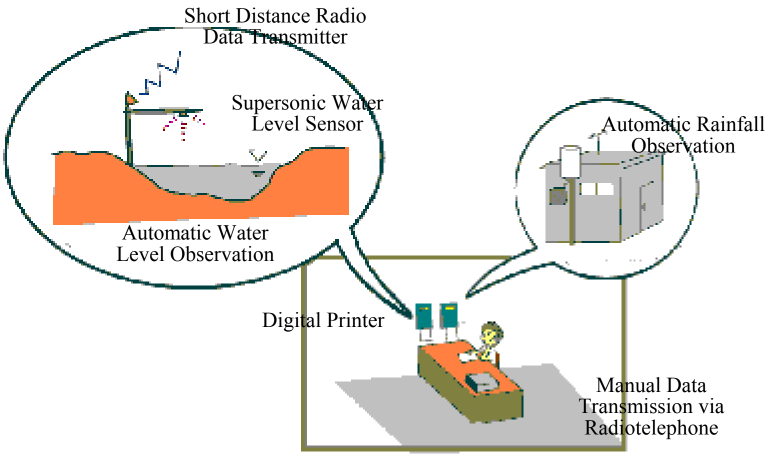
An automatic hydrological sensor is introduced to avoid data lacking, speed up observation and to enhance data reliability. A tipping bucket type rainfall gauge can measure every 0.5 mm tip of raindrop and send a signal to a remote terminal unit for data logging and printing. The observer reads printed data and sends them to DRHT via a VHF/FM or HF/SSB radiotelephone.

An ultrasonic water level gauge is recommended among several kinds of water level sensors. This water level gauge that does not need any structure in the water and can measure water level without touching the water at all is suitable for torrential flood flows containing a lot of sediment and debris. A comparison of water level gauges is summarized in Table 5.4.1.

(b) Communication between Water Level Gauge and Station

Generally a water level gauges is 100 to 500m away from its station house equipped with a radiotelephone. To avoid time loss for going and coming between the gauge and the station, an automatic transmission measure is proposed between them. A short distance radio data transmitter is installed at the gauge, and its receiver and a remote terminal unit at the station house respectively. Transmitted water level data are printed in the station house, and reported to DRHT through a radiotelephone together with rainfall data. In this system the observer does not have to go out from the station house to read water levels but he can read and report data, staying in the station house.

It is noted that this Option-B can be easily upgraded to a fully automatic system, Option-C by connecting radio equipment or an INMARSAT-C transceiver to the remote terminal unit.

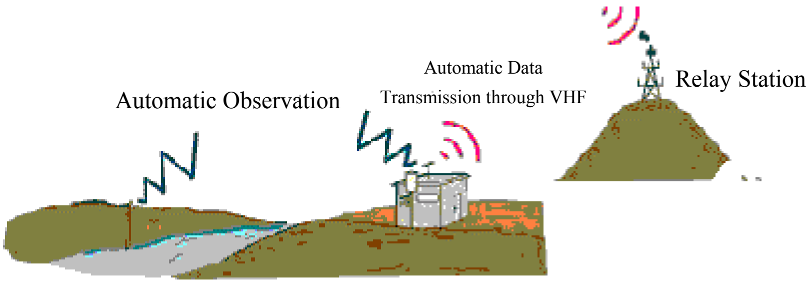


Semi-automatic System

(3) Option-C

Option-C is a fully automatic system from observation to data collection. Oral communication of Option-B is also replaced by automatic data transmission. This option coincides with the direction of the DGH action plan as discussed in Section 2.11.

A fully automatic hydrological observation system based on a telemetry system is introduced in this option. Data transmission methods by INMARSAT-C and by surface radio transmission are discussed and compared here. In conclusion, surface radio transmission by VHF/FM is tentatively proposed for the Study Area, as explained in Table 5.4.2. Equipment configuration is almost the same as Option-B except the radio system. However, relocation of observation stations must be considered, depending on radio propagation conditions.



Fully-automatic System

(a) INMARSAT-C Land Mobile Communication

INMARSAT-C land mobile communication is generally suitable for data communication for observation stations in isolated places like the Study Area, and its considerable low initial cost is also very attractive. However, this method has some disadvantages too. Due to its packet data transmission method via a Land Earth Station, delay of 5 to 15 minutes is inevitable. This delay can not be neglected for the Study Area where flood propagation is so fast. Its high running cost (operation fee and international telephone charge) is another problem.

(b) Surface Radio Communication

Surface radio communication is real-time communication. HF/SSB network has advantageous for long distance communication of 300 km to 1,000 km without any relay station. At the same time this is likely to get interfered by other radio networks. It is very difficult to ensure stable quality of communication due to its fading effects.

On the other hand, the direct service range of VHF /FM radio is as short as about 40 km even under a line-of-sight condition. Therefore, the longer the communication distance is, the more relay stations are required, resulting in an increase of the initial cost. Nevertheless, VHF/FM radio communication is generally recognized to be the most suitable for low speed data communication such as a hydrological telemetry system. Small running cost is also attractive. A schematic diagram of the VHF/FM radio network and the configuration of equipment are presented in Figs 5.4.1 and 5.4.2 respectively.

5.4.2 Three Options for Data Analysis, Forecasting and Data Distribution

(1) Option-A

This option follows the existing manual data processing. Collected hydrological data through a radiotelephone from the flood watch stations are compiled and recorded in a logbook. Water level-discharge conversion is also made manually based on previously prepared conversion tables. Data visualization and forecasting is also made manually. Distribution of flood data/information is made through a telephone or a fax as currently made.

(2) Option-B

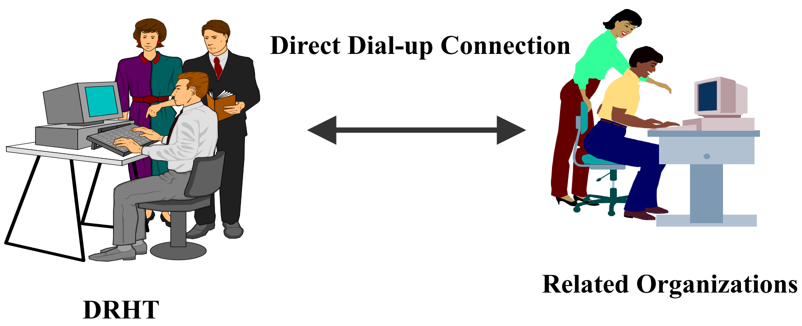
A computerized system is introduced in this option to speed up the procedure and to avoid human errors.

(a) Equipment for Data Analysis and Forecasting

The following criteria is assumed for designing of the configuration of equipment:

- Data storage capacity for two year hydrological data,
- Operation System of Windows NT and 98,
- Installation of application software for hydrological data processing and visualization and forecasting,
- Dual mode operation of PC servers for the backup purpose,
- Display and print distribution in Web style,
- Ethernet LAN network, and
- Easiness of future expansion.

A LAN is established in DRHT for data exchange among the computers. This total computer network consists of two sets of PC servers as Data base, two client PC for data analysis and processing, a remote access server for data communication with related organizations, one client PC for the director's room and peripheral equipment. NTP server and GPS receiver is provided for system time correction utilizing GPS standard clock. An UPS is provided to every server and PC against sudden interruption of the commercial power supply.



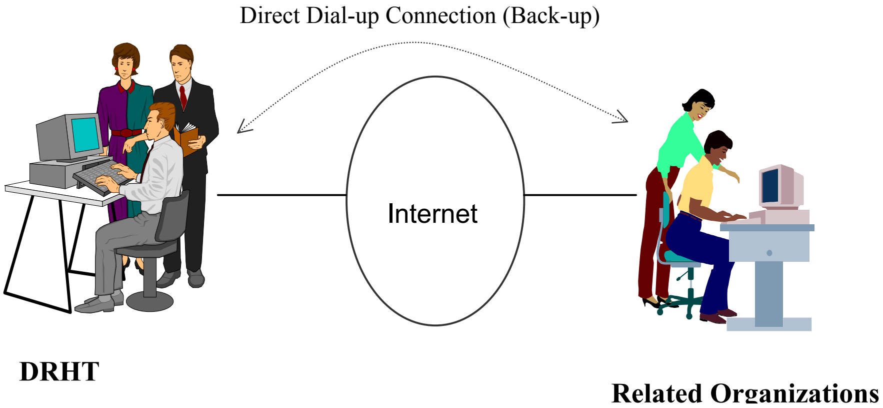
Information Distribution via Computer Network

(b) Data Distribution

As explained in Subsection 5.3.2, visualized flood information is distributed to related organizations to share the processed information among DRHT and them. A personal computer as data monitoring equipment that can access the data processing server of DRHT by dialing a V90 MODEM is installed at every monitor station (related organization). The lines between DRHT and the monitoring stations are usually off but can be on by dialing DRHT from the monitoring stations when necessary.

(3) Option-C

Internet is added to Option-B to deal with many monitoring stations. A homepage of DRHT is open at a reliable provider. Reliability of Internet providers is still doubtful at present, but it can be optimistically anticipated that the remarkably developing Information Technology can overcome this problem very soon. The monitoring stations can access the DRHT homepage through the Internet when necessary. For more important organizations involved in the FFWS such as DGH, DPEs, Al Haouz Province and its caidat offices, and Sidi Youssef Ben Ali Prefecture and its caidats, a direct dial-up connection to DRHT is added as a backup of Internet.



Introduction of Internet

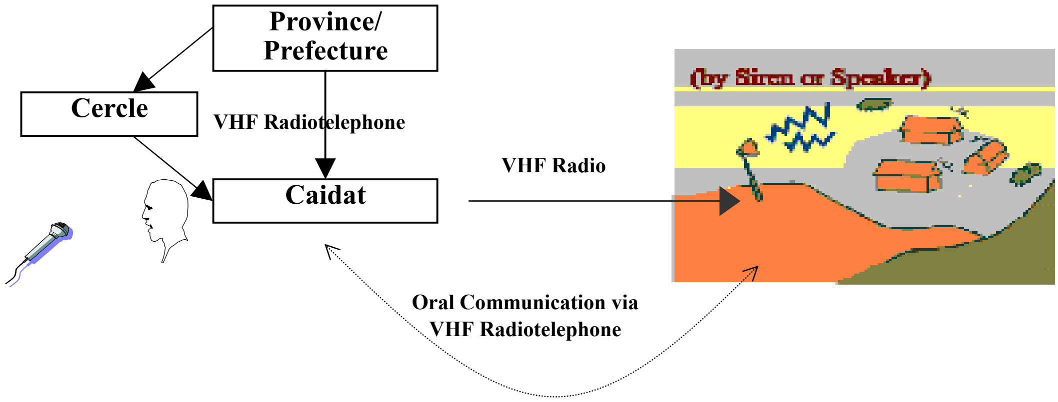
5.4.3 Warnings Dissemination

(1) Option-A

This manual option is not so different from the existing system. Only a voice amplifier with a loudspeaker for broadcasting warnings that is a so-called Warning Post is installed at 17 locations as shown in Fig. 5.3.3. Receiving a flood warning from the governor through the existing VHF radiotelephone, relevant caidats are to dispatch their men to the warning posts by car and/or on foot, to broadcast the warning message to inhabitants and/or tourists.

(2) Option-B

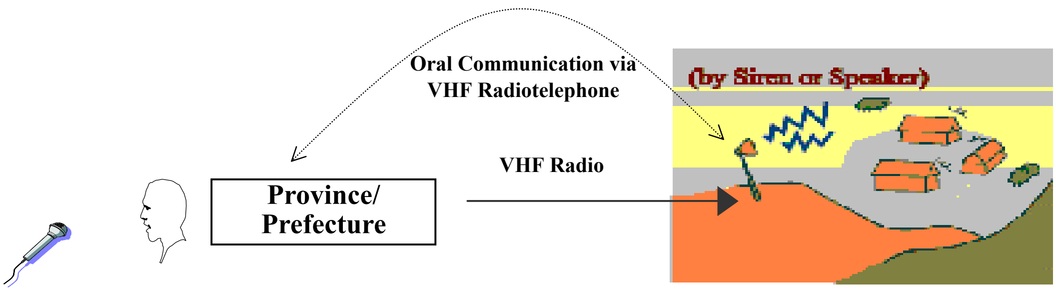
In this option, warning control equipment that enables remote control of warning posts is additionally installed at relevant caidat offices. Warning dissemination between the governor and relevant caidat offices are made by the existing VHF radiotelephone as currently made. The warning broadcasting at the warning posts is made remotely from the caidat offices through new independent VHF radio networks. These radio networks require non-noise circuit of which the Signal to Noise Ratio is less than –40dB, and three relay stations are to be newly installed for the VHF networks. Oral communication between a warning post and the relevant caidat office is also possible via a radiophone attached to the VHF network.



Warning Messages from Caidat

(3) Option-C

This option is an on-line direct dissemination system from the governor to the warning posts not via relevant caidat offices to reduce transmission time and to avoid man-made errors. Warning supervisory and control equipment is installed at the province/prefecture office. Once the governor has decided to issue a flood warning, recorded or live voice-messages can be sent through new independent VHF radio networks directly up to the warning posts without any human interface. This system requires radio propagation of such a high quality as the Option-B. Five new relay stations are necessary for this system. A schematic diagram of the VHF/FM radio network and the configuration of equipment are presented in Figs 5.4.4 and 5.4.5 respectively.



Warning Messages from Province/Prefecture

5.4.4 Selection of Optimum Equipment Plan

(1) Alternatives

Several alternatives of combinations of the three options conceived for each of the three subsystems are considered for the Master Plan. In this Study, to facilitate the selection of optimum one, three typical alternatives are set up as presented in Table 5.4.3 and summarized as follows:

- Alternative-A: Manual System (a combination of the three Option-As)
- Alternative-B: Semi-Automatic System (a combination of the three Option-Bs)
- Alternative-C: Fully Automatic System (a combination of the three Option-Cs)

The breakdown of equipment cost for the three alternatives is given in Table 5.4.4, and the three alternatives are compared as follows:

Comparison of Three Alternatives

Alternative	Equipment Cost (Million DH)	Accuracy	Necessary Time for Total Operation*
Alternative-A	5.7	Low	1.5 to 6 hours
Alternative-B	34.3	Medium	50 min.
Alternative-C	47.7	High	30 min.

* Necessary time for total operation from observation to evacuation (refer to Table 5.4.5)

(2) Selection of Optimum Alternative

Since disasters in the Study Area accompany loss of human lives as experienced in 1995, the necessity of the improvement of the FFWS is clear. In this Study, it is proposed from the following reasons that the Alternative-C (fully automatic system) be applied for the Master Plan:

- Introduction of an automatic system is the strategy of the action plan of DGH. In practice, automatic systems have been and will be applied in the other river basins such as Ouergha and Oum Er Rubia. Judging from these situations, introduction of an automatic system is in the same direction as the modernization of hydrological observation that DGH is promoting.

- The Aternative-A based on manual operation is not preferable if the long time necessary for the system operation from observation to evacuation (1.5 to 6 hours) is considered.

- There is not a big gap in cost between the Alternatives-B and C, while a considerable gap in accuracy and necessary time for system operation is seen between them. Especially, the necessary time can be shorten by as much as 20 minutes, which is significant for the FFWS in this mountainous area.

- The project evaluation in Subsection 5.8.1 reveals that the Alternative-C is evaluated to be generally viable in terms of economical effectiveness, financial affordability, social and technical acceptability, and environmental impacts. An EIRR of 14.2 % is estimated if loss of human lives is considered.

5.5 General Description of Master Plan

5.5.1 Objective of Proposed FFWS

The proposed FFWS (hereinafter referred to as the Atlas Region FFWS Plan) aims to protect inhabitants and tourists in the following high risk areas (refer to Fig. 5.3.1) from river flood and/or debris flow disasters by evacuating them appropriately in time:

High Risk Areas

River Basin	Prefecture/ Province	High Risk Area	
		Area	Type of Disaster
R'dat	Al Haouz	Tazlida Tributary	Debris flow
Zat	Al Haouz	Tiferent Douar	Debris flow
Ourika	Al Haouz	Tiguemmi-n-Oumzil et Tnite and the long stretch from Aghbalau to Setti Fadma	River Flood and Debris flow
Rheraya	Al Haouz	R'ha Mouley Brahim and Asni Market	River Flood
		Imlil	Debris Flow
N'fis	Al Haouz	T. N. Yakoub	River Flood
		Imigdal Tributary (Tisgui and Targa Douars)	Debris Flow
Issyl	Sidi Youssef Ben Ali	Municipality of Sidi Youssef Ben Ali and Guannoune Douar	River Flood

High risk areas other than those along the Issyl River that flows down Sidi Youssef Ben Ali Prefecture are all located in Al Haouz Province. At least a warning post is installed at every high risk area to warn inhabitants and/or tourists of a risk of a river flood and/or debris flow disaster.

5.5.2 Components of Atlas Region FFWS Plan

The Atlas Region FFWS Plan is a total system composed of five subsystems extending from hydrological observation and data collection to evacuation:

(1) Hydrological Observation and Data Collection

The Atlas Region FFWS Plan has 20 flood watch stations. 12 stations have both a rainfall gauge and a water level gauge, and the remaining 8 stations are rainfall stations.

All the flood watch stations are equipped with an automatic telemeter system that enables automatic measurement of rainfall and water level and real-time data transmission to DRHT. Usually the measurement and data transmission is made every an hour. Once rainfall of more than 1 mm is detected at any station, the interval of the measurement and transmission is changed into 10 minutes not to miss a sudden growth of the rainfall.

An observer that is recruited from a neighboring douar is assigned to each of the 18 stations except the Oukaimedan and El Azib-n-Tinzar stations that are located very far from populated areas. He lives with his family in the residence built next to the station and takes care of the measurement and radio equipment. When the equipment does not work properly, he is to measure rainfall and/or water level and transmit them to DRHT manually under the guidance of DRHT. A list of the flood watch stations is given in Table 5.3.1 and their locations are presented in Fig 5.3.1.

(2) Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices

The collected hydrological data are processed and analyzed in DRHT which plays a role of a master information center of the FFWS in the Study Area. Forecasting of a river flood and a debris flow is also made by DRHT. Based on the analysis and forecasting, DRHT is to announce Flood Notices that are defined in the Subsection 5.3.2. The Flood Notices and processed flood information are distributed to related organizations through the Internet, public telephone, fax, and/or VHF radiotelephone. Fig. 5.5.1 presents communication networks among related organizations involved in the FFWS, and Fig. 5.4.3 gives a schematic diagram of the computer network among DRHT (the Master Information Center) and its monitoring stations.

Recipients of Flood Notice

Classification	Recipient
Local Authorities	Relevant Province/Prefecture, Cercles and Caidats
Other Related Organizations	DGH, Relevant DPE, ONEP, ONE, ORMVAH,DMN

(3) Issuance of Flood Warnings

The governor of the Province/Prefecture is to issue Flood Warnings that directly call for caution and evacuation of inhabitants and tourists in the high risk areas, based on the Flood Notices announced by DRHT and other information. Definitions of the Flood Warnings are given in Chapter 2.

(4) Dissemination of Flood Warnings

The Flood Warnings are disseminated from the Province/Prefecture to warning posts and related organizations as shown in Fig. 5.5.1.

Recipients of Flood Warning

Classification	Communication Measure	Recipients
Warning Post	Warning Broadcasting System	Inhabitants and tourists
Local Authorities	Telephone, Fax, VHF Radiotelephone	Relevant Cercles, Caidats
Other Related Government Organization	Telephone, Fax	Royal Mounted Police, Civil Protection, Ministry of Interior, and other organizations involved in ORSEC Plan
Broadcasting Mass Media	Telephone, Fax	Mass Media (TV and Radio)
Tourism Related Industries (hotels, restaurants, etc.)	Telephone, Fax	Managers and Employees, then Tourists

The Atlas Region FFWS Plan has a total of 17 warning posts as shown in Fig. 5.3.3. These posts are provided with warning broadcasting equipment. Live or recorded warning messages are directly broadcast under the remote control of the Province/Prefecture.

As explained in Subsection 5.3.5, each warning post is managed by an evacuation organization made up of inhabitants of the douar(s). Its transmission cell is responsible for operation and maintenance of the warning post under the guidance of the Province/Prefecture. During a rainstorm members of the transmission cell are required to communicate with the Province/Prefecture through a VHF radiotelephone installed at the warning post. Fig. 5.4.4 gives a schematic diagram of the warning dissemination network.

Ordinary telecommunication measures such as public telephone and fax are used for the warning dissemination to the related organizations that are located far away from the possible disaster areas. For the lower local authorities such as cercles and caidats, the VHF radiotelephone network of the Province/Prefecture can be used.

(5) Evacuation

Evacuation must be made appropriately and promptly in accordance with an evacuation plan that is to be prepared for every high risk area. The evacuation plan must contain the following contents as discussed in Subsection 5.3.5:

1. Evacuation Organization
2. Operation of Warning Post
3. Evacuation Places and Routes
4. Stock of Materials and Equipment
5. Diffusion of Warning Messages
6. Guidance of Evacuees
7. Guidance of Tourists
8. Evacuation Drill
9. Public Relations
10. Evaluation of Evacuation Activities and Updating of Evacuation Plan

5.5.3 Strengthening and Systemization of Voluntary Disaster Prevention Activities

There are innumerable potential disaster areas in the Study Area, while the proposed Atlas Region FFWS Plan targets the high risk areas only. The low risk areas where damage potentials are estimated relatively lower than the high risk areas are actually still exposed to dreadful disasters. Even the high risk areas to be covered by the FFWS Plan will be not perfectly safe due to technical limitation of the forecasting methods for a river flood and a debris flow such as devastated mountainous areas. It might be risky for inhabitants to depend on the new FFWS alone so much. An universal principle of disaster prevention, "*Our lives must be protected by ourselves*" will be still essential even after the completion of the Atlas Region FFWS Plan.

In this context, inhabitants' voluntary disaster prevention activities that are currently based on their experiences and goodwill should be strengthened and systemized in both the high and low risk areas. The following voluntary activities will supplement the Atlas Region FFWS Plan that will be never able to eliminate all disaster damages in the Study Area:

- Establishment of an evacuation organization even in a low risk area,
- Handing down experiences from elder generations to younger generations,
- Refraining from building houses in flood and debris flow prone areas, and
- Rainfall observation.

Governmental organizations including the province, the prefecture, DPEs and DRHT is required to input technical supports including publicizing of hazard maps, giving advice on designation of evacuation places.

5.6 Operation and Maintenance Plan

5.6.1 Organizations Involved in Atlas Region FFWS Plan

As shown in Fig. 5.5.1, many organizations are involved in the Atlas Region FFWS operation. Among them, DRHT (ABHT), DPE Al Haouz, DPE Wilaya Marrakech, Al Haouz Province and Sidi Youssef Ben Ali Prefecture are considered as the principal organizations that play key roles in the Atlas Region FFWS operation.

The principal organizations have not only head quarters in the river flood- or debris flow-free flat plain but also local posts/stations in the Atlas Region. DRHT in Marrakech works as a flood information center and supervise the flood watch stations. DPEs that have their brigade posts for road maintenance are mainly concerned about maintenance of road traffic. Al Haouz Province and Sidi Youssef Ben Ali Prefecture are responsible for warning dissemination and evacuation guidance. The governor of the Province/Prefecture is to issue the Flood Warnings, which are broadcast at the warning posts. The governer is to dispatch patrol clues from relevant lower local authorities such as caidats to the risk areas.

Involvement of Principal Organizations in Atlas Region FFWS

Subsystem	DRHT		DPE		Province/Prefecture	
	DRHT in Marrakech	Flood Watch Stations	Head Quarter	Brigade Posts	Head Quarter	Warning Posts (Evacuation Org.)
Hydrological Observation and Data Collection	R, S, I	R, I	A, S	A, I	A, S	A, I
Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices	R, I					
Issuance of Flood Warnings	A		A		R, I	A
Dissemination of Flood Warnings					R, S, I	R, I
Execution of Evacuation			A, S	A, I	R, S	R, I

Note; R: responsible, A: assisting and supporting, S: supervising, I: implementing

5.6.2 Proposed Operation and Maintenance Plan

An operation and maintenance plan for the principal organizations is elaborated as follows:

(1) Flood Phase

To make clear actions and procedures to be taken in response to different stages of a flood, a flood period is divided into four Flood Phases, namely Normal Phase, Preparatory Phase, Flood Watch Phase and Evacuation Phase in an order of seriousness of the flood situation. The principal organizations, DRHT, DPE Al Haouz, DPE Marrakech, Al Haouz Province, Sidi Youssef Ben Ali Prefecture and the warning posts are required to take appropriate actions in accordance with operation procedures stipulated for each of the Flood Phases in the operation manual.

The DMN Pre-alert and Alert Messages and the DRHT Flood Notices are used for transition from one phase to another as explained below:

(a) Normal Phase

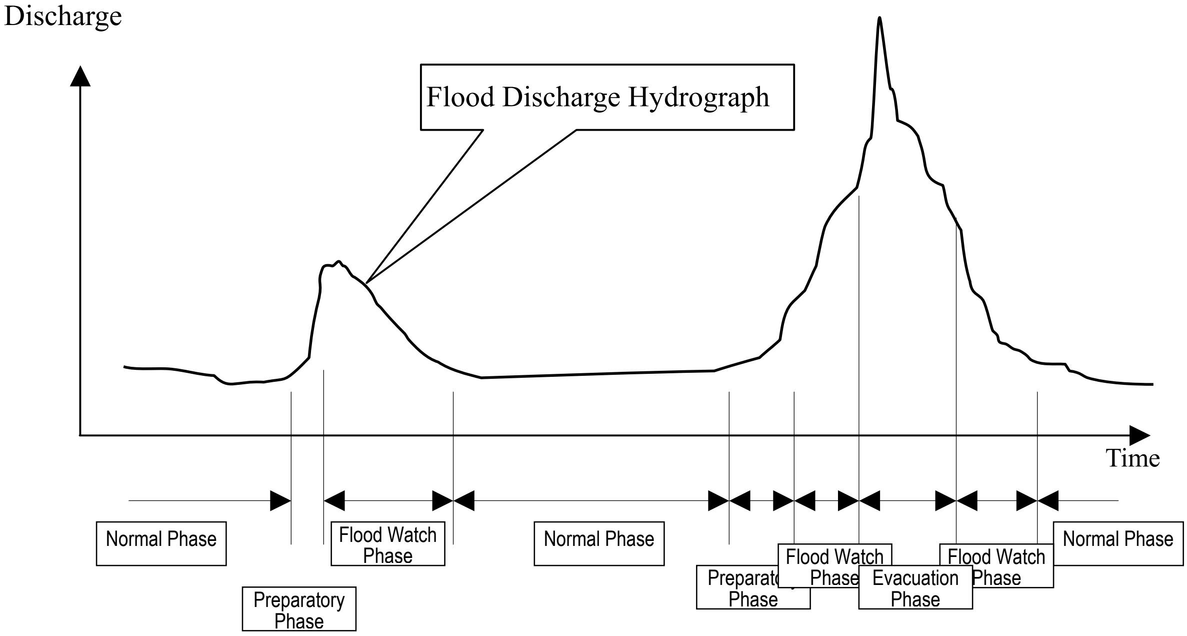
The Normal Phase is a pre-flood period or a post-flood period when the danger of a river flood and/or debris flows is not predicted at all.

Once a Pre-alert Message or an Alert Message has been announced by DMN during this phase for Al Haouz Province and/or Sidi Youssef Ben Ali Prefecture, the Preparatory Phase commences. Once a Pre-River Flood Notice and/or a Pre-Debris Flow Notice has been announced by DRHT for any warning post area during the Normal Phase, the Flood Watch Phase breaks directly.

(b) Preparatory Phase

The Preparatory Phase is usually a period when it is about to rain soon or it has already started to rain slightly.

Once a Pre-River Flood Notice and/or a Pre-Debris Flow Notice have been announced by DRHT for any warning post area, the Preparatory Phase terminates and the Flood Watch Phase commences. If the flood situation is not worsened, the Preparatory Phase terminates with termination of the DMN messages and the Normal Phase resumes.



Transition of Flood Phase

(c) Flood Watch Phase

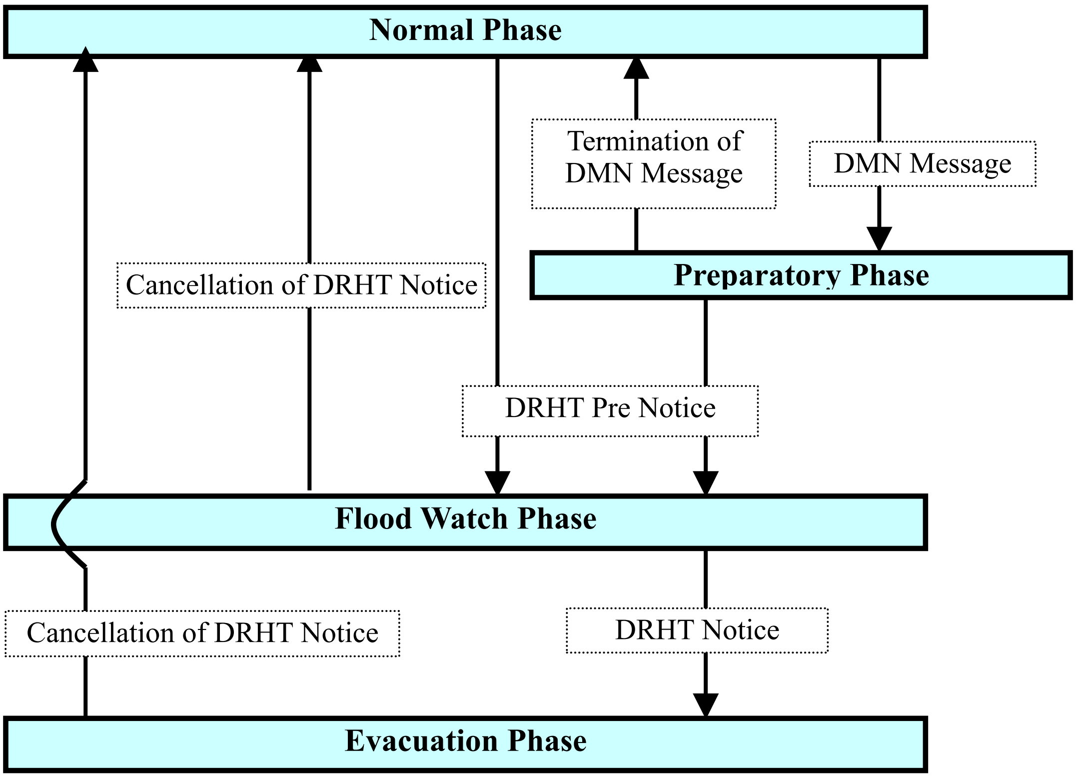
The Flood Watch Phase is a period when the flood situation has been worsened so badly that some symptoms of a flood and/or debris flows such as heavy rainfall and swelling of river water have appeared actually.

Once a River Flood Notice and/or a Debris Flow Notice have been announced by DRHT for any warning post area, the Flood Watch Phase terminated and the Evacuation Phase commences. Once the flood situation has settled enough for DRHT to cancel all the Pre-River Flood Notices and Pre-Debris Flow Notices, the Flood watch Phase terminates and the Normal Phase resumes.

(d) Evacuation Phase

The Evacuation Phase is a period when the flood situation has been worsened so badly that evacuation is necessary.

Once the flood situation has settled enough for DRHT to cancel all the River Flood Notices and the Debris Flow Notices, the Evacuation Phase terminates and the Flood Watch Phase resumes.



Transition of Flood Phase and Flood Notices

(2) Actions and Procedures to be Taken by Principal Organizations

Concrete actions and procedures that should be taken during each of the four Flood Phases by the principal organizations including their field stations and posts are listed in the operation manual, and summarized as follows:

(a) FFWS Operation during Normal Phase

In this phase no immediate actions are generally needed. In order immediately to respond to any subtle symptom of a storm including DMN messages at any time, however, the principal organizations must keep on duty 24 hours even in the Normal Phase. Moreover, the FFWS equipment shall be maintained in good condition.

The principal organizations, DRHT, DPEs, the Province and the Prefecture shall gather to have a meeting for updating of this operation manual, and to discuss on a joint communication drill in May or June, gathering representatives from their field offices and related organizations. The joint drill involving all the principal organizations shall be made in June, just before the tourist season. Before the joint drill, every organization must conduct an internal FFWS operation drill once a year at least to remind all the personnel concerned of the FFWS operation procedures. After every flood that reached the Preparatory Phase or further and every joint drill, all the principal organizations should meet after compiling each evaluation report on its FFWS operation, which is to be referred to for updating of the operation manual.

(b) FFWS Operation during Preparatory Phase

The most important thing during this phase is to get ready against a growing rainstorm. A FFWS operation team consisting of an engineer (or an officers) and some technicians shall be organized as soon as this Preparatory Phase commences, so as to respond to sudden development of the rainstorm.

The observers of the flood watch stations, the technicians of the DPE brigade posts and the caretakers of the warning posts also must stand by under the guidance of DRHT, the DPE Headquarters and the Province/Prefecture respectively.

(c) FFWS Operation during Flood Watch Phase

The Flood Watch Phase is a period when the flood situation has been worsened so badly that some symptoms of a flood and/or debris flows such as heavy rainfall and swelling of river water have appeared actually. Keeping watch on the flood situation is the most important task for all the principal organizations during this phase.

The flood situation often jumps to the Flood Watch Phase directly from the Normal Phase if a DMN message is not announced during the Normal Phase. If so, a FFWS operation team must be established immediately.

(d) FFWS Operation during Evacuation Phase

The Evacuation Phase is an emergent period when the flood situation has been worsened so badly that immediate evacuation of inhabitants and tourists is necessary at some warning posts. Prompt issuance and dissemination of Evacuation Direction is the most important during this phase.

5.7 Implementation Plan and Cost Estimate

5.7.1 Implementation Plan

As discussed in Subsection 5.1.3, the Atlas Region FFWS Plan (master plan) will be completed in 2009. On the other hand, a part of the master plan is implemented and completed in three years as a pilot project under this Study, as explained in Chapter 6. The pilot project, which targets the Ourika Valley, covers as much as almost 27% of the master plan. Once the pilot project is completed, about 73% of the master plan will remain for implementation.

Taking into account urgent necessity of the full implementation of the master plan, it is proposed that the remaining works be implemented continuously after the pilot project. A proposed implementation plan of the whole Atlas Region FFWS Plan is presented in Table 5.7.1, considering a necessary period required for every work.

Major Work Items and Necessary period

Work Item	Necessary Period (months)	Remarks
Administrative Arrangement of Tendering for F/S & D/D	6	
Feasibility Study (F/S)	6	
Administrative Arrangement for Acquisition of Radio Frequencies	(3)	Implemented in parallel with Feasibility Study.
Detailed Design (D/D)	6	
Financial Arrangement	3 (6)	Implemented in parallel with Detailed Design.
Administrative Arrangement of Tendering for Procurement of Equipment	6	
Manufacturing and Shipment of Equipment	15	Inspection by ANRT is included.
Civil Construction Work	(6)	Implemented in parallel with Manufacturing and Shipment of Equipment.
Installation of Equipment	6	
Training and Experimental Operation	12	
Total	60	

5.7.2 Cost Estimate

The project cost and the maintenance cost for the whole Atlas Region FFWS Plan including the pilot project is approximated as follows:

(1) Conditions for Cost Estimate

(a) Price Level

The price level is as of August 1, 2003. The currency conversion rates among US Dollar (USD), Moroccan Dirham (Dh) and Japanese Yen (JPY) are: USD 1.00 = Dh 9.8638 = JPY 120.590.

(b) Constitution of Project Cost

The project cost is composed of construction cost, engineering services cost, physical contingency. Since facilities to be built such as antenna poles and houses for storage of equipment are all very small in size and located in remote mountainous areas, compensation cost including land acquisition cost and house relocation cost can be neglected compared with the other costs.

The construction cost can be further divided into equipment cost (refer to Table 5.4.4), installation and commissioning cost, civil construction cost, software development cost and technical training cost. The physical contingency is estimated at 10% of the construction cost and the engineering services cost.

(c) Annual Operation and Maintenance Cost

Annual operation and maintenance cost is generally estimated at about 5% of equipment cost in Japan. The same value, 5% is assumed in this Study too.

(2) Project Cost and Conditions for Cost Estimate

Based on the above, the project cost and the maintenance cost are estimated as below:

Project Cost and Maintenance Cost for Atlas Region FFWS Plan

Cost Item		Amount (1,000 Dh)
A.	Construction Cost	**60,516**
	(1)Equipment Cost	47,747
	(2)Installation and Commissioning Cost	6,384
	(3)Civil Construction Work Cost	4,386
	(4)Software Development Cost	1,000
	(5)Technical Training Cost	1,000
B.	Engineering Services Cost	**15,000**
C.	Physical Contingency (10% of (A+B))	**7,552**
D.	Project Cost (A+B+C)	**83,068**
E.	Annual Operation and Maintenance Cost	**2,387**

5.8 Project Evaluation

The proposed Atlas Region FFWS Plan is evaluated comprehensively in this Chapter. In conclusion, the FFWS Plan is generally viable in terms of economical effectiveness, financial affordability, social and technical acceptability, and environmental impacts, as follows:

5.8.1 Economic Evaluation and Financial Considerations

(1) Cost-Benefit Analysis

(a) Economic Cost

A part of this Master Plan is to be implemented as a pilot Project under this Study. Almost all the implementation cost of the Pilot Project is to be borne by JICA. Therefore, the remaining cost of Dh 60 million that is obtained by subtracting the cost of the Pilot Project of Dh 23 million (refer to Subsection 10.4.2) from the total project cost of Dh 83 million is used for this cost-benefit analysis.

According to a recent World Bank's *Staff Appraisal Report, Kingdom of Morocco Water Resources Management Project*, following conversion factors are calculated as a function of the foreign exchange component of each cost category, the import duties on that foreign exchange component, and the value added tax applied to that cost category: civil works 0.77, equipment 0.63, consulting services 0.83. If these figures are applied to the Master Plan, economic cost is estimated at **Dh 49 million**, which is summarized in Table 5.8.1.

(b) Benefit Side

(i) Identification of the Benefit Items

The following benefits are basically expected by the implementation of the Master Plan from the viewpoint of their possibility of measure in monetary terms: evacuation of movable assets and promotion of tourism industry. Although reduction in the risk of human lives is also one of the benefits, it is discussed separately as a reference because it needs special consideration for the calculation of its value.

(ii) Evacuation of Movable Assets

Main movable assets to be evacuated in case of floods are livestock for residents and automobiles for tourists. A majority of residents evacuated carrying with nothing and only small number of people carried money and their household effects when they evacuated, according to the social study and public awareness survey by the Study Team. Please refer to **3.3 Social Analysis** for the details of the social study and public awareness survey. After the implementation of the Master Plan, it is expected that residents will be able evacuate some of their household effects. Personal effects carried by tourists should be very limited.

Economic value of livestock. Cattle: Dh 6,975, sheep: Dh 791, goat: Dh 372, mule: Dh 3,255 and donkey: Dh 465.

Economic value of automobile: Dh 75,000.

Household Effects: Dh 6,000 per house lost.

(iii) Promotion of Tourism Industry

According to the survey on the present conditions of the tourism spots, the number of automobiles and tourists visiting almost reaches the full capacity of the facility such as parking lots and roads. In addition, there is no concrete future development plan for tourism in the Study Area. It is very difficult to forecast that the number of tourists would increase drastically in the future without additional investment in tourism development. It is estimated that the direct GDP contribution per tourist per day is Dh 58.9 and indirect effect is Dh 17.7. With 1% increase in the present number of tourists for 2001-2010 thanks to the Master Plan, the benefit would be Dh 6.2 million although the detailed figure is not clear with the available data.

(d) Economic Evaluation

(i) Data Availability

Data/materials recorded by authorities in the area is very limited for the purpose of the economic evaluation.

- Data on flood damage have been hardly prepared so far. As for damage amount, we have such data only in 1995 and 1999.
- Because the flood forecasting and waning system, which is the objective of the Master Plan, is a non-structural measure against floods, its targets for damage reduction are some of movable assets (a part of household effects, automobiles and livestock). However, past flood damage data do not necessarily recorded detailed contents of damage.

Thus, the Study compensates the lack of necessary data by conducting the following surveys:

- Topographic surveys and hydraulic/hydrological analysis
- Public awareness survey

Please refer to **3.2 Hydrological and Hydraulic Analysis** for the details of the topographic surveys and hydraulic/hydrological analysis, and to **3.3 Social Analysis** for those of the public awareness survey.

(ii) Reported Damage by Past Floods

According to the Ministry of Equipment, the Ministry of Agriculture and the

Regional Police Office as well as the survey by the Study Team, reported damage by floods in 1995 includes agricultural land which is washed away, lost livestock, automobiles, houses, roads and other public facilities as well as human lives. The total amount of losses are reported at Dh 70 million by DGH and the total number of fatalities is reported at 289 while the economic value of moveable asset losses is estimated at Dh 19.96 million (the number of lost cattle: 1,725, goats: 1,447, and automobiles: 83, and some household effects), (please refer to Table 5.8.2).

Concerning to the 1999 flood, no losses on automobiles and human lives are reported thanks to off-season timing. The economic value of moveable asset losses is estimated at Dh 0.08 million (the number of lost sheep: 10, goats: 12, and some household effects), (please refer to Table 5.8.3).

(iii) Fatalities from Past Floods

It is reported that 289 persons are killed by 1995 flood, according to the Royal Mounted Police report. The most are dead in Ourika. Its breakdown is as follows: 263 in Ourika, 14 in Aito Ourir and 12 in Asni.

The report describes the flood in Ourika as follows. The alarm was launched at about 8:00 pm on August 17th 1995 and water level decreased at the Ourika Bridge at about 10:00 pm. The traffic towards Setti Fadma became impossible starting from the Ourika Brigade. The floodwaters had submerged the road. The search for discovering corpses started from the next day. The final result was as follows:

- Number of non-identified corpses: 129;
- Number of identified corpses that were buried by their families: 51 including 23 males and 28 females;
- Number of corpses identified by their families and buried by the local authorities: 6 including 5 males and 1 female; and
- Missed persons: 7.

(iv) Annual Average Damage

This Study employs a simplified way that estimates a probability-damage correlation on movable assets directly with the damage by the past two floods due to data availability. It is assumed to be in proportion to the length of road submerged which is calculated by the computerized hydrologic simulation model. With this estimation, an annual average damage to movable assets is calculated. Its detailed procedure is as follows:

1) The computerized hydrologic model simulates the floods with the return periods of 2, 5, 10, 20, 30, 50 and 100, and the length of the submerged road is calculated with each return period;

2) The damage by the flood with each return period is estimated in proportion to the length of the road submerged;

3) In 2), two series of damage are estimated; one is based on the actual damage in 1995 (return period: 30 years) and the other is based on the actual damage in 1999 (return period: 20 years);

4) The annual average damage is a weighted average of the two series in 3) because the flood in 1995 broke out on tourism season and that in 1999 off-season; and

5) The weight for on-season is determined at 1/6 and that for off-season at 5/6 based on the hydrological data.

The calculation results shows that the annual average damage to movable assets is **Dh 0.72 million** (please refer to Table 5.8.4). When the value of human lives (Dh 1371,555 per person) is included in this calculation, the result comes to **Dh 14.65 million** (please refer to Table 5.8.6). Please note again these results have a considerable error that can be realized in the calculation process and the data availability.

(v) Economic Evaluation

Benefit

The benefit of the Master Plan is identified as the value which is expected to be reduced in the annual average damage on movable assets by the implementation of the Flood Forecasting and Warning System. The benefit from the promotion of tourism industry is excluded here because the effect on it is not clear with available data.

The reduction in the annual average damage amounts to **Dh 0.72 million** on the assumption that all the movable assets would be escaped from the flood damage (please refer to Tables 5.8.4). Although it would be difficult to expect the benefit can be realized fully in reality, it can be deemed as the maximum expected amount of the benefit.

EIRR, B/C and NPV

The next step is to calculate Economic Internal Rate of Return (EIRR), Benefit-cost ratio (B/C) and Net Present Value (NPV) in order to examine the economic viability of the Master Plan. Firstly, cash flow tables are made with the annual average benefit, construction cost and O&M cost in accordance with the implementation schedule (please refer to Tables 5.8.5). Then, EIRR, B/C and NPV are calculated based on the cash flow tables as follows:

EIRR, B/C and NPV

EIRR	Negative*
B/C	0.07
NPV	-Dh 60 million

Note: * EIRR cannot be calculated numerically because the benefit is too small comparing with the construction cost and O&M cost.

Examination of Results

As shown in the above table, EIRR is very small because the benefit from reduction of damage on movable assets is minimal. B/C and NPV also present the same results. As long as we consider the Master Plan only with these results, it is not economically viable. However, it is not preferable to consider the economic viability without taking into consideration the benefit of the reduction in the risk of human lives which is one of the main objectives of the project.

***Reference for Economic Evaluation**

This part tries to include the value of human lives because one of the major objectives of the Master Plan is to reduce the risk of human lives, or to save human lives. Usually, the value of human lives is not included in economic evaluation of infrastructure projects in ODA schemes due to the difficulty of calculation as well as data availability. It should be noted that the figures used in this part are presented for a reference purpose and be treated with much care.

Value of Human Lives

The value of a life means here the value of a statistical life, not the value of the life of a particular person. In other words, it is the value of one less death in a population on average.

Past studies in industrialized countries including US, UK and Australia show a wide range of estimated amounts, from £130,000 to £7,950,000 at 1987 prices or more than sixty times. Gramlich, M. E. (1990), *A Guide to Benefit-Cost Analysis*, notes that a human life is estimated from $2.5 million to $5 million at 1988 prices by the method of labor market studies. On the other hand, Boardman, A. E., et al. (1996), *Cost-Benefit Analysis Concepts and Practice* shows $2 to $3 million for North American applications at 1990 prices as a rule of thumb.

In order to apply the results of the labor market studies in the US to the Master Plan, it is assumed that the value of life estimated is in proportion to per capita GDP of the country.

The value of a life in the US at 1998 prices is estimated at $3.5 million if we refer to the data in Gramlich, M. E. (1990) and Boardman, A. E., et al. (1996). The ratio of per capita GDP between US and Morocco is 25.3. Therefore, the value of a life in Morocco is calculated at $139,308 at 1998 prices or **Dh 1,371,555** at 2000 prices.

Benefit

If all the people were saved, the total benefit would be **Dh 14.65 million**, which represents the annual average of damage on movable assets and human lives (please refer to Tables 5.8.6). Although it would be difficult to expect the benefit can be realized fully in reality, it can be deemed as the maximum expected amount of the benefit.

EIRR, B/C and NPV

The next step is to calculate Economic Internal Rate of Return (EIRR), Benefit-cost ratio (B/C) and Net Present Value (NPV) in order to examine the economic feasibility of the Master Plan. Firstly, cash flow tables are made with the annual average benefit, construction cost and O&M cost in accordance with the implementation schedule (please refer to Tables 5.8.7). Then, EIRR, B/C and NPV are calculated based on the cash flow tables as follows:

EIRR, B/C and NPV

EIRR	14.2%
B/C	1.4
NPV	Dh 25 million

<u>Examination of Results</u>

Results are drastically changed, depending on whether the value of human lives are included or not. If the value of a human life is included, EIRR exceeds 14% as the benefit from reduction of damage increases significantly. B/C and NPV also present the same results. It is expected that the project is economically feasible with considering the benefit of the reduction in the risk of human lives which is one of the main objectives of the project.

(2) Financial Considerations

(a) Budget of Related Authorities

(1) DGH

DGH controls the hydrology-related budget of DRHs and allocates the budget. Allocation of some budget items is decided after the collection of requests from DRHs. The Hydrology-related budget which is to be allocated to regional DRHs amounts to Dh 7.2 million in 2000/01. All the hydrology-related operating budget amounts to Dh 11.2 million. Please refer to Table 5.8.8.

(ii) DRHT

As mentioned above, hydrology-related budget of DRHT is controlled by DGH while administrative and personnel budgets are by DRE. DRHT has no direct budget for purchase and O&M of electronic devices. Hydrology-related budget of DRHT is Dh 737,960 in 1999/2000 (please refer to Table 5.8.9 for details).

(iii) Al Haouz Province

The Budget of Al Haouz Province in 1999/00 is as follows. The total budget allocation to the Province is Dh 18.6 million. On the expense side is as follows: personnel costs (salaries, benefits and transportation costs are included): Dh 6,775,300, total operating budget: Dh 3,210,400 and total equipment budget is Dh 8,355,000.

(b) Cost Burden on Local Authorities

Since securing O&M budget is very important for sustainability of the project and local authorities are responsible for O&M, affordability of O&M cost by local authorities are discussed here. DRHT should care data processing sub-system and data collecting sub-system, and Al Haouz Province some of monitoring stations and warning dissemination sub-system, and Sidi Youssef Ben Ali (SYBA) Prefecture should care some of warning equipment. It means that the local authorities should bear such O&M cost. Since the budgets of local authorities are much more limited than that of the Central Government, special considerations should be required after the implementation of the Master Plan.

According to the technical consideration, the annual O&M cost is estimated at 5% of the equipment cost. Annual additional burdens are Dh 1,502,000 on DRHT, Dh 722.000 on

Al Haouz Province and Dh 163,000 on SYBA Prefecture (please refer to Table 5.8.10 for details). It should be noted that theses O&M costs are estimated only for the reference purpose because the equipment cost is estimated with accuracy in the Master Plan stage. Accurate O&M costs should be estimated at the detailed design stage. Actual costs would change according to maintenance contracts with the suppliers.

Concerning DRHT, the annual O&M cost exceeds its hydrology-related budget (about Dh 700,00). It is required that DGH increase the budget allocation to DRHT for the proper operation of the new FFWS. Since the hydrology-related operating budget, amounts to Dh 11.2 million in 2000/01, the amount necessary to increase for DRHT is 13% of this budget. Although, the amount is not small, it is expected that DGH manages to increase budget allocation to DRHT, taking it into consideration that improvement of FFWS is promoted as a part of National strategy by the Ministry of Equipment, and FFWS modernization has already been promoted in other regions.

Concerning Al Haouz Province, annual cost for O&M amounts to 3.9% of its total budget or 22% of its operating budget in 1999/00. The O&M cost is not small either in this case. It is also expected, however, that the Ministry of Interior manages to expand the subsidy to Al Haouz Province for keeping the O&M of the equipment because local collectivities are responsible for protecting people from disaster and it is one of the most important functions for them.

5.8.2 Consideration of Social Aspect

Master plan needs to be evaluated from the viewpoint of social aspect so it has to be discussed as a matter of public concern in order to recognize its significance for the local people. Based on all output data and information of the interview survey, social characteristics of the communities in the river basins can be summarized as follows:

- Rural infrastructure and availability of public services are still far beyond the satisfactory level,
- Although agriculture is the base of regional economy, crop production is not sufficient to cover their own consumption,
- Apart from agriculture, employment opportunity can be hardly found in the study area, and
- As a result, young manpower is flowing out of the village to be engaged in other income sources in urban area as a means of economic support for the family.

From the above situation, it is understood that local people are in a very hard position from a socioeconomic point of view. They eke out a living from day to day. Under such a precarious living condition, it is somewhat difficult to call their attention to the flood forecasting and warning system.

However, local residents realize the necessity to take some preventive measures against natural disaster for securing their lives and property, but they do not know what to do and how to approach this question, and consequently, no pre-emptive action has been taken by themselves. They expect that the Government will show them an idea of alleviating threat to disaster and take necessary measures to mitigate flood damages. It means there is no way to go ahead without leadership of the Government.

Evacuation drill or exercise may be a good example. People have never experienced in such a drill or exercise, but about 83 % of them gave an affirmative answer in the interview survey to participate in the drill if it would be planned by the authority. It is further important to consider the fact that 97 % of all respondents answered that the flood forecasting and warning system is necessary for the security of their communities, and many of them are even disposed to contribute something to the said system. It is apparent that people do not know what the system is like technically, but they are well aware that it is something quite useful for flood prediction.

Giving consideration to the above message from the local people, the Government is required to take the initiative in giving them guidance on risk management for natural disaster and should take action at the earliest time possible to motivate people's mind. In this regard, it should be noted that cooperation with other institutions and agencies concerned is absolutely important to attain satisfactory result.

As master plan is intended to outline a comprehensive task oriented approach to the regional development, it will certainly help improve the present situation for public interest. The plan should be socially acceptable and mutually understandable between the proponent and residents/stakeholders. Therefore, public opinion and people's reactions to the plan have been fully examined in the social study and as a result, there seems to be neither controversial issue nor negative observation.

The following are main points to keep careful watch on and can be expected to come true for the benefit of local communities and residents:

- To enhance people's reaction capability and their consciousness of disaster preparedness and management,
- To develop self-reliance by promoting and encouraging the spirit of self-help and mutual assistance among local authorities and communities,
- To provide security coverage in disaster area ensuring the safety of human lives and minimization of property loss,
- To encourage tourist activities in holiday-making spots by taking measures on disaster prevention, control and mitigation, and
- To establish communication linkages between local authorities and their constituents and to make these available for information dissemination.

While flood forecasting and warning system is to be operated under the joint responsibility of DRHT, DPE and local Government, its effectiveness will largely depend on the skills and resources and involvement of local authorities and communities. The plan comprises various aspects on non-structural measures and may not include significant requirement for large-scaled construction works and relocation of people. Therefore, it is not detrimental to the natural environment and will not cause a negative campaign by the general public against the plan. It is expected that the plan is beneficial to the emergency preparedness and may lead to the improvement of social environment

5.8.3 Initial Environmental Evaluation

(1) Objectives and Methodology

(a) Objectives

The Initial Environmental Examination (IEE) is the first step in the process of preparing the Environmental Impact Assessment (EIA) for a project. The scope of this Study covers the IEE for the Atlas Region FFWS Plan. The Initial Environmental Examination (IEE) shall attempt to identify whether any impacts on the environment may be expected from the implementation of the FFWS Plan on the Study Area. Basically the IEE has the following two objectives:

- To evaluate whether EIA is necessary for the FFWS Plan and, when necessary to define the items which are expected to have negative environmental impacts.
- To consider from the environmental point of view countermeasures for alleviating the effects of the FFWS Plan, which would be the subject for detailed examination at the Environmental Impact Assessment phase.

(b) Methodology

The IEE study shall be conducted taking into consideration the Moroccan draft EIA law and decree (discussed in Section 2.10 of this report), and guidelines developed by JICA and other international aid agencies. The need for EIA based on these considerations is as follows:

<u>Moroccan Draft EIA</u>

This M/P does not fall under the project categories, which require EIA as determined in the draft executive regulations accompanying the decree. Furthermore Article 2 of the decree exempts projects ordered by the government from EIA. It is assumed that the projects developed in the FFWS Plan will be adopted by the national government because of the savings in lives they are developed for.

<u>World Bank</u>

In a 1989 policy paper the World Bank developed four project categories in order to determine the necessity for EIA as follows:

- Category A: Projects which normally require an EIA
- Category B: Projects which may need some limited environmental review
- Category C: Projects which normally do not need an environmental analysis
- Category D: Environmentally beneficial projects and emergency recovery projects

Considering the benefits in savings in human lives the FFWS Plan will bring to the social environment it may easily be argued that these projects will fall under Category D of the World Bank ranking.

<u>Japan International Cooperation Agency (JICA) Guidelines</u>

JICA has developed environmental guidelines for a pre-IEE study, which is implemented at the time of preparation of the Study Scope of Works between the Japanese government and the government of the country receiving the development study. According to this pre-IEE study, which was implemented by the JICA Preparatory Study Team in November – December 1999, the need for an IEE in this Study to determine impacts on certain environmental aspects was considered necessary.

The IEE has accordingly been prepared as follows:

- Understanding the FFWS Plan components, implementation method and phasing
- Developing an appreciation of the environmental setting in which the FFWS Plan projects shall be implemented through data collection and site reconnaissance visits
- Screening and scooping as defined hereafter
- Recommendations for countermeasures to offset any potential environmental impacts and determination of the need for implementation of a full EIA

(2) Implementation of IEE

(a) Project Components

The Atlas Region FFWS Plan has been presented in this chapter. The FFWS Plan components subject to the IEE are summarized as follows:

- New construction:
  1) Observation Stations (for equipment related to rainfall and water level measurements) (12 stations)
  2) Residences of observers (for observers and their families) (14 residences)
  3) Relay stations (tower and attached small building for equipment) (6 stations)
  4) Warning posts (post with attached loudspeaker) (17 posts)
- New equipment: Measurement equipment for rain gauges and water levels, data transmission and sirens for warning

(b) Screening

Environmental aspects are screened in order to identify environmental impacts on natural and social conditions, which should be examined in more detail if a full-scale environmental impact assessment is deemed necessary.

The result of the screening of the project is shown in Table 5.8.11. The results of the analysis show that further environmental examination is required for the master plan projects effect on the social environment aspects of resettlement, public health, waste and risk. In the case of the natural environment there is the need to consider further any effect on the soil erosion, landscape and fauna and flora.

(c) Scooping

The purpose of scooping is to clarify any significant impacts, which may be caused by the master plan projects. The results of the scooping, implemented under the JICA guidelines are shown in Table 5.8.12.

No serious impacts are predicted from the master plan project implementation however there are some items where it is recommended to make further examination. For some of these items the implementing agency is legally bound to make further examination in consultation with other government agencies such as the ministry of culture (for protection of culture property), the water basin agency to be created under the Water Act (Law No. 10-95) (for resettlement and economic activities), the municipality officials (for resettlement requirements) and the water and forests department (for protected areas and flora and fauna). Therefore it is considered that there is no need to study these aspects in an independent environmental evaluation, as they will be considered by competent agencies.

Other aspects of concern such as construction waste, safety against landslides and wastewater drainage shall be studied in the design of the facilities and again it is considered that an independent environmental evaluation is not necessary.

(3) Conclusion of IEE

The potential environmental impacts as determined from the screening and scooping process are summarized in Table 5.8.13.

Due to the small scale of the project facilities and the procedures in place that must be followed before project implementation it is considered not necessary to make an environmental impact assessment study.

5.8.4 Technical Acceptability

To ensure sustainable operation of the proposed Atlas Region FFWS Plan, fatal breakdown of equipment and systems should be in principle repaired by their suppliers under a maintenance contract. However, a certain level of technical capacity, which enables emergent operation during a flood and daily maintenance of equipment at least, is required for every execution organization in the FFWS Plan.

Subsystems and Responsible Organizations

Subsystem		Responsible Organization
Hydrological Observation and Data Collection Subsystem		DRHT
Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices Subsystem	Master Information Center	DRHT
	Monitoring Stations	DPE, Province, Prefecture, Cercles, and Caidats and Others
Warning Dissemination Subsystem		Province, Prefecture, Evacuation Organizations (Warning Posts)

The most high-tech and sophisticated subsystems are the Hydrological Observation and Data Collection Subsystem and the Master Information Center for the Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices Subsystem. The both subsystems are to be operated and maintained by the Service of Hydrology of DRHT that is currently composed of 13 persons including two engineers.

Since the two systems will be totally new to the personnel of the Service, technical transfer by consultants and suppliers involved in the implementation of the Plan is indispensable for ensuring the sustainable operation of the FFWS Plan. This is the reason why as long as 12 months is proposed for training and experimental operation in the implementation schedule given in Table 5.7.1. Operation drills are also important for the personnel to maintain and develop their knowledge and skills. The pilot project in which a part of the Atlas Region FFWS Plan will be implemented earlier will be also an great opportunity of such technical transfer. In addition, DGH and DPEs are expected to assist DRHT technically. Especially DGH who has similar projects such as those in the Ouergha and Oum Er Rbia River Basins is requested to support DRHT as practiced so far.

The Warning Dissemination Subsystem is also very new to the province and the prefecture that have less technical capacity. Technical transfer shall be made so carefully to their transmission cells after the installation of equipment that the personnel of the cells can operate the systems. Technical supports are also expected from related organizations such as DRHT, DPEs and Ministry of Interior.

In conclusion, the proposed Atlas Region FFWS Plan will be technically accepted through raining programs, experimental operations, operation drills and the pilot project.

5.9 Recommendation for Institutional Strengthening

5.9.1 Responsibility Allocation and Cooperation among Related Entities

For reliable FFWS, clear responsibility allocation and definite assignment of every task to a specific position of related organization should be prescribed and these responsibility allocation and assignment should be published and known by all of the related organizations.

Principally, the Director of DRHT is responsible to prepare and issue Flood and Debris Flow Notices, while the Governors of Al Haouz Province and Sidi Youssef Ben Ali Prefecture are responsible to prepare and issue Flood and Debris Flow Warning, and to prepare and guide evacuation of residents and tourists. Although the Governors are responsible for subsequent relief activities, relief activities are out of the scope of the Study and are not discussed in this report. The Governors and the director are also responsible to revise and update the plan of FFWS within their jurisdiction and scope of their responsibilities. They are also responsible to secure comprehensiveness of the FFWS, consulting one another and with related organizations.

Although DPEs of Al Haouz and Wilaya Marrakech should take major roles in FFWS, their responsibilities are limited to those for assistance and supports to DRHT and the Province/Prefecture, and the DPEs' activities for FFWS should be controlled by DRHT or the Province/Prefecture. DPEs should also take primary role in rehabilitation activities after flood or debris flow although rehabilitation activities are not dealt in this report.

Since DRHT and the Province/Prefecture only cannot execute FFWS activities promptly or efficiently, coordination with DMN, DPEs and other related organizations, such as tourism related industries would be required. With the progress of decentralization and wider spread of mass communication media, involvement of rural communes and broadcasting entities, such as RTM (Moroccan Radio and Television), will become more important. Coordination with organizations of Civil Protection, Police or Royal Gendarmerie, ONEP (National Office of Potable Water), ONE (National Office of Electricity), ORMAVAH (Regional Office of Agricultural Development of Al Haouz), medical entities, or Moroccan Red Crescent is important for relief and rehabilitation activities, thus only timely information flow to these entities are examined in the Study.

5.9.2 Organization Setup

In order to realize the proposed FFWS in the Atlas Region, i) establishment of additional flood watch stations, ii) establishment of new organizations, such as warning posts and iii) organizing task forces for evacuation of tourists by tourism relating industries are necessary. To strengthen coordination for enhancing preparedness, iv) frequent periodical meeting among related organization held by DRHT and the Province/Prefecture is necessary. Examination for v) involvement of rural communes and vi) use of broadcasting entities should be started to cope with future change in local administration and life style of the people in the region.

(1) Establishment of Additional Flood Watch Stations

For the FFWS proposed in the Master Plan, additional twelve flood watch stations are planed. In principle, current management can be applied to the additional stations because of little problems in the existing stations. Due to the introduction of new equipment for automatic measurement and data transmission which is not used at the stations in the region and not widely spread in Morocco, however, maintenance system of the equipment should be enhanced. The cell for equipment maintenance should be strengthened with assured budget for the maintenance.

(2) Establishment of Warning Posts

For the efficient establishment of warning posts, installation of warning equipment in some existing institutions, such as schools or mosques, should be examined. After the selection of locations of the installation, two or three caretakers for a warning posts are be nominated among the persons destined to the existing organization for shifts of permanent duty (24 hours a day) whose costs are to be born by the Province/Prefecture. Initial explanation on the FFWS and operation and daily inspection of the warning equipments is inevitable. Periodical inspection and maintenance is the responsibility of the Province/Prefecture with assistance of DRHT and the relevant DPE.

(3) Organizing Tourism Related Industries

Managers and employees of tourism related industries, such as hotels, restaurants and souvenir or other shops, are willing to assist evacuation of tourists, and they have capability to do it. After designation of evacuation places and planning of evacuation guidance by the Province/Prefecture, organizing task forces constituted of managers and employees of the local tourism related industries is recommendable.

At first, nomination of task managers and assignments of duties required for evacuation guidance of tourists are to be made through meetings by the relevant Province/Prefecture and tourism related industries of the location. The task manager should preferably be a manager of a large hotel or restaurant which have a telephone line to be used for direct instruction from the Province/Prefecture. Then, the task force should work out detail evacuation plan by themselves suitable to each conditions of the area and submit the plan to the Province/Prefecture for approval. After the approval of the plan, they should assist evacuation of the tourists as planned.

The task force should also participate in evacuation drill held every year before the tourist season, evaluate their performance by themselves and revise their detail plan based on their self-evaluation and the evaluation by the Province/Prefecture.

(4) Periodical Meeting to Enhance the Preparedness and Strengthening Cooperation

Frequent and periodical joint meetings with the initiative of DRHT and the Province/Prefecture and with participation of all major relating are recommendable to attain preparedness at any time, to make FFWS reliable and to enable prompt and proper activities at the time of floods and debris flows. At least, meeting should be held at following times.

a) Every May to prepare the drill of the year
b) Every June to evaluate the performance in the drill and to revised operation plans, lists and formats of FFWS
c) After evacuation, relief and rehabilitation activities of actual floods and debris flows evaluate the actual performance and to revised operation plans, lists and formats of FFWS

(5) Involvement of Rural Communes

Decentralization is gradually proceeding and capability of rural communes will grow. According to the progress of decentralization, involvement of rural communes in FFWS should be considered for prompt operation suitable to the local conditions. In the timeframe of the Master Plan, however, rural communes would not be able to take major responsibility in FFWS. Rather, preparation for rural communes to take major role should be examined and started. At first, involvement of rural communes in dissemination of cautions/warnings issued by the Governor, in evacuation guidance and in controlling the task force for tourist evacuation. Then day-to-day management of warning posts with technical and financial assistance of the Province/Prefecture could be a target of the involvement of rural communes in the Master Plan.

(6) Use of Mass Media in Dissemination of Flood Notice and Warning

With more diffusion of radio and TV in the high risk areas of the region, use of these mass media will become more effective and efficient. At the same time, however, information dissemination with these media may cause misunderstanding by public in large scale if the dissemination is not well-organized. Checks and control in the course of dissemination through these media should be carefully examined. Discussions by DRHT and the Province/Prefecture with broadcasting entities and their supervising organization, such as ministry in charge of communication, should be started.

5.9.3 Required Human Resource Development

With the introduction of new system and equipment, as well as organization set-up for the FFWS proposed in the Master Plan, the following training would be required.

(1) DRHT and Flood Watch Stations

First, few engineers and several technicians should be explained or trained by the staff in DGH/DRPE, Study Team, and contractors for installation of the equipment on whole operation and maintenance required for data collection, flood forecasting and transmission of the Notices to related organizations with the system proposed in the Master Plan. Then, observers at flood watch stations should be explained and trained by DHRT, the Study Team, and contractors for installation of the equipment on operation and daily inspection for the measurements data transmission to DRHT headquarters.

Training and research/development by them self to enable to revised the criteria and parameters for forecasting and issuance of notices with accumulation of measurements and data storage would be very important to develop further reliable FFWS. Assistance of DGH/DRPE would be necessary.

(2) The Province/Prefecture and Warning Posts

Responsible persons, such as the Governors, and heads of the Civil Protection Division and Transmission Cell of the Cabinet in the Province/Prefecture should be explained on the whole FFWS by the DRHT, Study Team, and contractors for installation of the equipment. Thereafter, a few communication operators in the headquarters and a few caretakers for each warning post should be trained on matters required for warning operation and daily inspection of the equipment.

(3) Other Organizations

Responsible persons in DPEs and the main staff of the Water Service should be explained on the whole FFWS by DRHT, Study Team and the Province/Prefecture. Later, personnel in the Water Service and relevant brigades and should be trained by the main staff of the Water Service of the respective DPE on matters required to carry out assignment. Initial explanation on the whole system as well as on the assignment would be made to the managers and core staff of the related organization, such as the task force composed of the managers and employees tourism related industries.

CHAPTER 6. PLANNING AND DESIGN OF PILOT PROJECT

6.1. Planning of Pilot Project

A part of the draft Master Plan proposed in the previous chapter is implemented in three years between 2001 and 2003 as the Pilot Project. This Pilot Project aims to examine the adequacy of the draft master plan proposed in the previous chapter through the experimental operation of installed equipment and systems for a certain period. The draft master plan is modified and updated after a close evaluation of the Pilot Project in the following chapters.

6.1.1 Selection of Objective River Basin

The Ourika River Basin is selected among the six river basins as the objective river basin for the Pilot Project from the following reasons:

(1) Typical River Basin of Study Area

The Ourika Basin that includes possibilities of all kind of rain-induced disasters such as river flood, debris flow, landslide and slope failure can be regarded as a typical river basin of the Study Area in terms of potential disasters. Thus equipment and systems to be introduced in the Ourika River Basin under the Pilot Project could be applicable to the other river basins, as they are or with small modifications. It seems natural to test the draft Master Plan in the representative river basin, the Ourika River Basin.

(2) Utilization of Existing Facilities

There are six flood watch stations existing in the Ourika River Basin. Since these facilities can be utilized for the Pilot Project too, it costs less to install the Pilot Project equipment in the Ourika River Basin than the other river basins.

(3) Available Hydrological Data

The Ourika River Basin is the richest in rainfall and water level data among the six river basins. These available hydrological data can be used to determine alert levels of rainfall and water levels.

(4) Urgency of Introduction of FFWS

In spite of a lots efforts made by the Moroccan Government after the 1995 flood, the Ourika River Basin is still under the threat of all kinds of rain-induced disasters, attracting hundred thousands of tourists every summer on the contrary. In order to minimize disaster damages, it is urgently required to introduce a FFWS in the Ourika River Basin.

6.1.2 Determination of Development Level

In order to avoid double investments in future, the Pilot Project should be implemented in the framework of the Master Plan. Therefore, the Pilot Project could be something intermediate in quantity and/or quality between the existing condition and the Master Plan. As seen in Table 6.1.1, there is still a big gap between the existing condition and the Master Plan. In other words, many alternatives of different development levels for the Pilot Project are conceivable between them. In this subsection some development levels are proposed and examined in view of cost and time for implementation. Then an optimal development level is determined within the budgetary and time limit of this Study, to concrete contents of the Pilot Project.

(1) Alternatives

In this Study four development levels are considered as alternatives. Three alternatives 1-1, 1-2 and 1-3 are at different intermediate levels less developed than the Master Plan. The alternative 2 is at the full development level of the draft Master Plan, limited to the Ourika River Basin. Details of the four alternatives are presented in Table 6.1.2 and are explained as follows:

(a) Alternative 1-1

This alternative is the least development case and aims to improve, to a minimum extent, subsystems that are not functioning virtually or at all. Improvement is made on three subsystems of data analyses, issuance of warning and execution of evacuation as shown in Table 6.1.3.

Master Information Center where data processing and flood forecasting are made using a computer is established at DRHT. The processed flood information is provided to related organizations through a dial-up computer connection. Guidelines are prepared for the issuance of flood warnings and execution of evacuation.

(b) Alternative 1-2

This alternative is a more developed case that adds to the alternative 1-2 automatic hydrological observation equipment and a warning post as shown in Table 6.1.4. With the automatic rain and water level gauges, the guardians of the flood watch stations will be able to obtain rainfall and water level data, staying at the station. This system can be regarded as a semi-automatic system.

The warning post that is equipped with a radiotelephone and broadcasting equipment is established at the busiest tourist spot along the Ourika Valley, Iraghf. The radiotelephone is linked to the existing radio network of Al Haouz Province, and a siren is to be blown from the post to warn tourists and inhabitants when ordered by the province.

(c) Alternative 1-3

This alternative is a further developed case that adds an automatic data transmission system to the alternative 1-2, to complete a automatic telemetry system by incorporating it with the automatic observation equipment as shown in Table 6.1.5. For the automatic transmission system, a VHF radio network is to be established with two new repeater stations.

(d) Alternative 2

This alternative is the same as the Master plan in the Ourika River Basin as shown in Table 6.1.6. A telemetry system that is composed of the 6 existing and 5 new flood watch stations is to be provided in the basin. Not only at Iraghf but also at 5 other tourist spots along the valley a warning post is to be provided. The 6 warning posts are to be directly controlled by the Province through a VHF radio network. The flood forecasting model and the related guidelines are to be updated to fit to the fully developed telemetry and warning systems.

(2) Comparison of Alternatives

The four alternatives are compared from the aspects of cost and time for implementation. An implementation program is roughly made for each alternative to count the necessary implementation time as shown in Table 6.1.7. Equipment cost is also estimated for each case as shown in Table 6.1.8. The cost and the implementation time is summarized as follows:

Comparison of Cost and Necessary Time for Implementation

Alternatives	Equipment Cost (million Dh)	Necessary Time for Implementation (month)
Alternative 1-1	3.8	9
Alternative 1-2	9.5	11
Alternative 1-3	16.9	21
Alternative 2	29.2	27

(3) Selection of Optimum Development Level

In conclusion, Alternative 1-3 was selected as the optimum development level of the Pilot Project from the following reasons:

- The telemetry system that is the most high-tech core part of the Master Plan is developed in Alternative 1-3, although the number of the telemetry flood watch stations is still five (5), much less than eleven (11) of the Master Plan. The implementation of the telemetry system can be a meaningful experiment for evaluation of the proposed Master Plan.

- Both of 21 months of the necessary implementation time and 16.9 million Dirhams of the equipment cost exceed the original plan of JICA. However, these matters might still be in a permissible range with some readjustments.

Fig. 6.1.1 compares the procedures of the existing system and the Pilot Project system.

6.2 Description of Pilot Project

6.2.1 General Description of Pilot Project

(1) Components of Pilot Project

The Pilot Project covers all the five principal subsystems as a total FFWS and aims to improve the existing system in the Ourika River Basin to some extent, as follows:

Constitution of Pilot Project

Subsystem	Phase I (Completed in December 2001)	Phase II (Completed in July 2003)
Hydrological Observation and Data Collection	Automation of hydrological observation at 5 flood watch stations (Provision of automatic tipping-bucket rain gauge and ultra sonic water level gauge)	Automation of data transmission (Provision of VHF radio data transmission system with 2 repeater stations)
Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information	Establishment of Master Information Center at DRHT and Monitoring Stations at DGH, DPE Al Haouz, Al Haouz Province and	Upgrading of data processing system along with introduction of telemetry system.
Issuance of Flood Warning	Preparation of Guidelines and Experimental Operation	
Dissemination of Flood Warning	Establishment of Iraghf Warning Post	Provision of selective call system among Iraghf Warning Post, Al Haouz Province and Ourika Caidat.
Execution of Evacuation	Preparation of Guidelines	

(2) Procurement of Equipment

Equipment for the Pilot Project are purchased in Japan by JICA under the scheme of "JICA Development Study", and then are shipped to Morocco.

(2) Implementation Schedule of Pilot Project

The Pilot Project is implemented step-wisely to ensure enough time for the Moroccan counterparts to get used to new Japanese equipment and system. The first phase is installed in October and November 2001, and the second phase is installed in June and July 2003, as presented in Table 6.2.1.

Almost all subsystems except for the hydrological Observation and Data Collection subsystem, is completed in the first year 2001. This system of the first phase can be regarded as a semi-automatic system because the automation of hydrological observation is attained at least. About 1.5 years after the first installation is spent for experimental operation of the semi-automatic system, while the procurement of the second phase equipment is made in Japan. The semi-automatic system is farther upgraded into an automatic telemetry system by incorporating an automatic data transmission system into the automatic observation equipment in 2003.

(3) Procurement of Equipment

Equipment for the Pilot Project are purchased in Japan by JICA under the scheme of "JICA Development Study", and then are shipped to Morocco.

(4) Installation

Installation is made by a local contractor under the supervision of Japanese engineers dispatched from the Japanese supplier.

(5) Limitation of Pilot Project

It is stressed that the Pilot Project is still less than half way on the way to the Master Plan even for the Ourika River Basin where new equipment are installed. Compared with the Master Plan, the Pilot Project system is still incomplete, although the Pilot Project system certainly can contribute to modernization of the FFWS in the Ourika River Basin and then to reduction of flood damages.

The most important difference is the number of flood watch stations and warning posts. Only five flood watch stations are automated and a warning post is newly created in the Pilot Project while eleven flood watch stations and six warning posts are proposed in the Master Plan, as shown in Fig. 6.2.1. With the five flood watch stations alone it is still difficult to forecast such a flash flood as the 1995 flood a certain sufficient time in advance before the flood reaches flood risk areas. The five flood watch stations that are all located on the main rivers could not detect debris flows in the small tributaries. The only one warning post at Iraghf hardly can cover all the river stretches subjected to flood and debris risks.

Comparison between Master Plan and Pilot Project in Ourika River Basin

Subsystem	Item	Master Plan	Pilot Project
Hydrological Observation and Data Collection	Number of Flood Watch Stations	11 (6)	5 (3)
Dissemination of Warning	Number of Warning Posts	6	1

Note: Number in the parentheses is number of the flood watch stations equipped with both a rain gauge and a water level gauge. The other stations are equipped with a rainfall gauge only.

6.2.2 Description of Pilot Project by Subsystem

(1) Hydrological Observation and Data Collection

The following five flood watch stations will be upgraded in the first year 2001 by introducing automatic gauging sensors.

Flood Watch Stations to be upgraded

Station	Type
Tazzitount	Rainfall and Water level Station (Non-separate Type)
Tourcht	Rainfall Station
Tiourdiou	Rainfall and Water level Station (Separate Type)
Amenzal	Rainfall and Water level Station (Separate Type)
Agouns	Rainfall Station

The existing VHF and HF radiotelephone networks are still used for data transmission until these stations is further upgraded in 2003 by introducing an automatic data transmission system using a new VHF radio network. Fig. 6.4.3 presents the VHF radio network.

(a) Rainfall Station

A tipping bucket type rain gauge that enables measurement of every 1 mm raindrop are placed on the roofs of the two stations, Tourcht and Agouns. This automatic rain gauge is connected for logging and displaying of data by a cable to a remote terminal unit (RTU) that is installed in the station house. With this new system the observer will be able to read indicated data and report them to DRHT (ABHT) through a VHF radiophone, only staying in the station house without going outside for measuring.

(b) Rainfall and Water Level Station

Besides the automatic rainfall gauge, an ultrasonic water level gauging sensor is also provided to the three rainfall and water level stations. This high-tech sensor that is fixed by a long arm over the water surface can measure the water level without touching the water at all.

According to the data transmission method between the water level gauging sensor and the station, the water level and rainfall stations are classified into two types, namely separate type using radio and non-separate type using a cable. These water level data transmitted via radio or a cable are logged and displayed at a RTU in the station house together with rainfall data.

The separate type of which water level gauge is located hundreds of meters away from the station uses radio data transmission. A short distance radio data transmitter is attached to the gauge, and its receiver that is connected to the RTU is installed in the station house on the other hand. The Tiourdiou and Amenzal Stations belong to the separate type.

The Tazzitout Station is a non-separate type station. The water level gauge is so close to the station that a cable can be used to directly connect the gauge to the RTU in the station house.

(2) Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information

Rainfall and water level data are collected from the flood watch stations to DRHT (ABHT) through the existing VHF radiotelephone network in the first phase of the Pilot Project, and then an automatic data transmission system (telemetry system) is introduced in the second phase. In the Pilot Project a data processing system that processes the raw hydrological data into visualized information, is established in DRHT (ABHT). For information sharing, the data processing system will be accessed through telephone lines by the four related organizations, DGH in Rabat, DPE Al Haouz, Al Haouz Province and the Ourika Caidat. A flood forecasting program composed of the SCS Method and the Maskingum Method is also developed in the first phase.

With the data processing system and the computer network, DRHT plays a role of a Master Information Center and the other organizations will monitor flood information by accessing the data processing system in DRHT.

(a) Master Information Center at DRHT (ABHT)

This data processing system consists of a PC server (database server), a client PC for data processing and forecasting, a remote access server for data communication with the monitoring stations and a NTP server with a GPS receiver for system time correction. Software for data keying-in, data storage, processing, flood forecasting and information distribution is also incorporated into the system. In 2002 an telemetry supervisory and control system is additionally incorporated to the data processing system.

(b) Monitoring Stations

A computer with a V90 Modem is installed in each of the four organizations (monitoring stations). Once informed by DRHT of a flood occurrence, the monitoring stations are to dial the data processing system in DRHT to receive flood information.

(3) Issuance of Warnings

The procedure of warning issuance that was proposed in the Interim Report 2 is modified and operated experimentally for the Ourika Valley in the Pilot Project period. In the procedure Flood Warnings are issued by the governor of Al Haouz Province mainly based on Flood Notices announced by DRHT (ABHT)

The Flood Notices are messages on flood situation announced by DRHT to call for necessary actions of related organizations against a probable river flood. Three kinds of Flood Notices are defined for river floods.

Based on collected flood information including the Flood Notices, the governor finally issues the Flood Warnings, which inhabitants and tourists are advised to follow. Three kinds of Flood Warnings are defined for the Ourika Valley, and are related to the Flood Notices to help the governor or his substitute issue the Warnings promptly and appropriately.

(4) Dissemination of Warnings

A warning post is newly created at a tourist spot on the Ourika River, Iraghf (Oulmes). This warning post consists of a VHF radiotelephone, a voice amplifier and two sets of loudspeakers. The radiotelephone and the amplifier are installed at in a house newly built by DRHT. Each set of loudspeakers connected with the amplifier by a cable is installed at the top of a pole built along the river, about 600 m away from the other.

The VHF radio telephone is connected to the existing network of the Province. In the second phase of the Pilot Project, in 2003, a selective call system is added to the radio telephone of the warning post. A new radiotelephone with the selective call system is also newly installed at each of Ourika Caidat and the Province in the second year, to enable closed communication among the three.

(5) Evacuation

Guidelines for evacuation activities at the Iraghf area are compiled in the Pilot Project. Some evacuation drills are also executed there in the Pilot Project.

6.3 Design of Pilot Project Phase –I (Semi-automatic system)

6.3.1 Ambient Conditions

All the equipment and materials shall be operational and/or durable under the following ambient conditions:

Ambient Conditions

Items	Outdoor Equipment	Indoor Equipment	Computers and Peripherals
Temperature	-15°C to 50°C	10°C to 40°C	15°C to 35°C
Relative humidity	90 % or less	20% to 80% non-condensing	20% to 80% non-condensing
Withstand wind speed	50m/sec.	N/a.	N/a.
Location of Installation	460m to 2,200m above sea level	460m to 2,200m above sea level	460m to 1,000m above sea level

6.3.2 Specifications and Configuration of Equipment

Detailed specifications of the major equipment for the Pilot Project Phase-I are given in the Volume 3, Supporting Report Appendix I: Telemetry and Warning System. Configurations of the total Pilot Project, equipment of the Master Information Center and the Monitoring Stations, the flood watch stations, and the Iraghf Warning Post are also illustrated in Figs. 6.3.1, 6.3.2, 6.3.3 and 6.3.4(1/3) respectively, together with the second phase equipment.

6.3.3 Specifications of Flood Forecasting Software

A flood forecasting program based on the USSCS Method and Muskingum Method is developed and installed in the client personal computer of the Master Information Center of DRHT. Required functions of the developed program are as follows:

(1) Data Import

The program imports latest processed rainfall and discharge data from csv data files that are created by the Data Import & Export Software of the client personal computer.

(2) Location and Period of Forecast

The flood forecasting program can forecast discharges in three hours at two tourist spots, Iraghf and Setti Fadma

(3) Forecasting Model

The flood forecasting model is composed of a runoff calculation model from sub-basins and a flood propagation model in the river. The USSCS Model and the Muskingum Method are applied as a runoff calculation model and a flood propagation model respectively.

(4) Future Rainfall Scenario

The following three scenarios of future rainfall are automatically employed for flood forecasting:

- The rainfall intensities increases (pecimistic scenario),
- The rainfall intensity continues (moderate scenario)
- The rainfall intensity decreases (optimistic scenario)

In addition to the above scenarios, the program allows the operator to optionally define the future rainfall.

(5) Real-time Updating

To make the most use of observed information, calculated discharges are adjusted to those observed at the water level stations, Amenzal, Tiourdiow and Tazzitount.

(6) Visualization of Forecast Results

Results of forecasting are visualized in a form of hydrographs together with rainfall data. Forecasted discharges shall be compared with user-defined pre-alert and alert discharges.

(7) Management of parameters

The forecasting program has a function that enables the operator to modify user-defined parameters such as model parameters and pre-alert and alert discharges.

6.4 Design of Pilot Project Phase-II (Automatic system)

6.4.1 Design of Radio Circuit for Telemetry System

In the second phase of the Pilot Project, which is to be installed in 2003, an automatic data transmission system will be added to the semi-automatic system of the first phase to complete a telemetry system for the Ourika Basin. The telemetry system aims to automatically collect the hydrological data from the flood watch stations to the Master Information Center, DRHT (ABHT) in Marrakech on real time basis through telecommunication media.

In this Section, designing of the telemetry network is described. Firstly low band VHF radio wave is selected as a telecommunication medium for the telemetry system among several media. Then its radio circuit was designed preliminarily through an examination of the topography of the Ourika Basin and conditions of verbal communication using the exiting VHF radiotelephones, and then a radio circuit calculation. The radio circuit was finalized through a series of field radio propagation tests.

(1) Selection of Communication Medium

Many kinds of communication media are conceivable for establishment of such telemetry system. HF, VHF and UHF radio circuits, satellite communication, public telephone line and Internet as well as mobile telephones can be regarded as prospective communication media.

An examination on characteristics and installation and operation costs of each communication medium was made to find out the best medium for the Ourika River Basin under the master plan study as discussed in Subsection 5.4.1. In this subsection the examination was carefully reviewed, and 70 MHz band VHF radio was selected in due consideration of characteristics of the media and their operation costs. Table 6.4.1 compares characteristics of the conceivable media for the Pilot Project.

The 70MHz band VHF is broadly used for telemetry systems in Japan, most of which are those for mountainous areas like the Ourika River Basin. Low Band VHF radio network that can reach a certain distance and is less affected by obstructions is considered suitable for the Pilot Project.

According to ANRT, VHF radio frequencies of 78 to 85 MHz are available for the telemetry system of the Pilot Project fortunately.

(2) Preliminary Radio Circuit Design

Generally composition of radio equipment for data transmission is not different from that for verbal communication at all. However, data transmission requires a radio linkage of higher quality than verbal communication. Verbal communication is dull to noises but data transmission is very sensitive. It is said that human beings can comprehend voice messages containing some noises, even those of less than 0dB/μV in receiving signal. On the other hand, data transmission for a telemetry system needs such a high quality radio linkage as 30dB/μV in receiving signal and about 40 dB in signal to noise ratio (S/N ratio), depending on the data transmission speed.

In due consideration of the above requirements for data transmission, a preliminary radio circuit was designed through an examination of the topography of the Ourika Basin and conditions of verbal communication by the exiting VHF radiotelephones, and then a radio circuit calculation.

(a) Examination of Topography

Topography is one of the most influential factors of radio propagation. Generally topographical maps with a scale of 1/50,000 or more are necessary for knowing ups and downs along radio paths, but such a precise map is not available for the Ourika River Basin unfortunately. A 1/100,000 map, "OKAIMEDAN – TOUBKAL" by Ministry of Agriculture was used instead for this purpose.

Plotting the five flood watch stations and the Oukaimedan Repeater Station on the map, it is easily understood that the four stations except the Agouns Station are located in the bottoms of deep valleys. High mountain walls behind and/or in front of the stations could be obstacles for radio propagation. The Agouns Station, which is located on a high mountain slope, seems a little better than the others.

Topographical profiles that are drawn for the spans between DRHT and every flood watch station and between the Oukaimedan Repeater Station and every flood watch station, show ups and downs and reveal obstructions on the spans. All the spans connecting the flood watch stations to DRHT are totally obstructed by high mountains. These spans are far inapplicable as the radio circuit. The other spans regarding the Okaimedan Repeater Station, which are also blocked by mountains, are not so expectable either. Some more repeater stations might be necessary.

(b) Examination of Verbal Communication by Existing VHF Radiotelephone.

Conditions of verbal communication by using the existing VHF radiotelephones also give precious information on radio propagation. Verbal communication among the stations still contains some noises, although its quality has been greatly improved since heightening of the antenna of the Okaimedan Repeater Station in December 2002. In particular, communication with the Amenzel, Tiourdiou and Tourcht Stations are more affected by noises. HF radiotelephones are mainly used instead for the Amenzal and Tiourdiou Stations where a HF radiotelephone has been additionally installed. This also means necessity of repeater stations for them at least.

(c) Radio Circuit Calculation

The radio circuit calculation is to estimate attenuation of radio waves by topographical influence. The topographical profile data are incorporated to a calculation model, and receiving levels and signal to noise ratios (S/N) are output as indicators for evaluation of the radio spans.

(i) Conditions for Radio Circuit Calculation

The following is conditions for the VHF radio circuit calculation:

Design Criteria for VHF Radio Circuit

Item	Applied Conditions
Frequency band	88MHz
Land Coefficient	- 10dBM
Modulation mode	Equal to frequency modulation
Occupied frequency band	12KHz
Maximum modulation frequency	3KHz
Antenna polarization	Vertical
Maximum frequency shift	3.5KHz
Noise figure	8dB
Ideal signal to noise ratio (S/N) in dB	S/N = 30 + Lc + Mm + Fm where Lc (Fixed deterioration margin) = 2.5dB, Mm(Maintenance margin) = 1.0dB, and Fm(Fading margin)= 0.1dB/Km + 3dB

(ii) Preparation of Provisional VHF Radio Network

As a result of the above examinations, two new repeater stations are conceived. They are the Aoulouss Station just behind the Tourcht Station and the Adrar Tazaina Station behind the Amenzal Station. The Aoulouss Repeater Station can probably relay the the Tourcht and Tazzitount Stations, while the Adrar Tazaina for the Amenzal and Tioudiou Stations. A VHF radio network with the three stations including the existing Oukaimedan Station is provisionally set up for the radio circuit calculation.

(iii) Calculation Result

By using a radio circuit design program, the radio circuit calculation was made to estimate receiving levels and signal to noise ratios (S/N) for a total of 17 spans of the provisional network, as shown in Fig. 6.4.1.

Focusing more on S/N, evaluation of each radio span is made by comparing the calculated S/N with its ideal value. If the calculated one is greater than the ideal value, the span is considered good enough. Even if the calculated one is less than the ideal one, the span is still possibly considered applicable if the difference remains within 5dB. The span is considered inapplicable if the calculated one is further less than the ideal one.

The evaluation results are summarized in the following table. Receiving levels of the thee spans between Oukaimeden and Aoulouss, Oukaimeden and Agouns, and Adrar Tazaina and Tioudiou are lower than the standard level of 30dB/μV, their higher S/N can make up for the low receiving levels.

As evaluated in the previous examinations, the spans directly connecting the flood watch stations are all evaluated inapplicable. The spans between the Oukaimedan Repeater Station and the four flood watch stations except the Agouns Station are also evaluated inapplicable. In conclusion, necessity of the two new repeater stations, Adrar Tazaina and Aoulouss was confirmed at least, although the calculation accuracy is not so high due to the rough topographical data read in the 1/100,000 map. The final designing of the radio network still have to wait for results of field radio propagation tests.

Result of Radio Circuit Calculation

No.	Station code	Transmission Station	Station code	Receiving Station	Distance (km)	Receiving level (dB/μv)	Ideal S/N (dB)	Evaluation
1	MS=A	Marrakech	RP=A	Oukaimeden	51.30	48.7	45.6	Good
2	MS=A	Marrakech	TM=03	Tazzitount	49.25	2.5	20.0	Inapplicable
3	MS=A	Marrakech	TM=04	Tourcht	61.30	-	Less than 0	Inapplicable
4	MS=A	Marrakech	TM=05	Amenzal	67.00	-	Less than 0	Inapplicable
5	MS=A	Marrakech	TM=06	Tiourdiou	55.30	-	Less than 0	Inapplicable
6	MS=A	Marrakech	TM=07	Agouns	54.00	-	Less than 0	Inapplicable
7	RP=E	Aoulouss	RP=A	Oukaimeden	23.40	28.5	42.8	Good
8	RP=A	Oukaimeden	TM=05	Amenzal	13.70	-	Less than 0	Inapplicable
9	RP=A	Oukaimeden	TM=06	Tiourdiou	12.20	2.0	10.0	Inapplicable
10	RP=A	Oukaimeden	TM=04	Tourcht	22.80	-	Less than 0	Inapplicable
11	RP=A	Oukaimeden	TM=03	Tazzitount	20.50	3.0	15.0	Inapplicable
12	RP=G	Adrar Tazaina	RP=A	Oukaimeden	12.00	33.7	36.7	Fair
13	TM=07	Agouns	RP=A	Oukaimeden	6.20	28.5	36.1	Fair
14	TM=03	Tazzitount	RP=E	Aoulouss	6.50	63.6	36.0	Fair
15	TM=04	Tourcht	RP=E	Aoulouss	6.20	73.3	35.7	Fair
16	TM=05	Amenzal	RP=G	Adrar Tazaina	1.00	74.3	35.7	Fair
17	TM=06	Tiourdiou	RP=G	Adrar Tazaina	4.80	18.6	35.8	Fair

Note: Evaluation

Good: Calculated S/N is greater than ideal one.

Fair: Calculated S/N is less than ideal one but the difference is less than 5dB.

Inapplicable: Calculated S/N is less than ideal one and the difference is greater than 5dB.

(3) Radio Propagation Test

Following the preliminary examination, a series of field radio propagation test were conducted from 24 May 2001 to 14 June 2001 for several target spans. Results of the propagation tests were utilized to finalize the telemetry network and the equipment design of the Pilot Project Phase-II.

(a) Methodology

For the field radio transmission test, two teams are necessary. One is a transmitter team and the other is a receiver team. Firstly the two teams stand their antennas at the target station sites respectively. The transmitter team transmits actual radio waves, and the receiver team measures radio signal strength, S/N, vertical and horizontal patterns of received radio waves. In addition, extents of radio interferences by other communications are also monitored.

(i) Spans

A total of 13 spans were selected as the test spans as shown in the following table:

Combinations of Transmitting and Receiving Stations

No.	Transmitting Station	Receiving Station	Distance (KM)
1	Marrakech	Oukaimeden	51.3
2	Marrakech	Adrar Tazaina	56.0
3	Marrakech	Aoulouss-2	56.0
4	Marrakech	Aoulouss-1	55.5
5	Oukaimeden	Adrar Tazaina	12.0
6	Oukaimedan	Aoulouss-2	23.0
7	Oukaimedan	Agouns	6.5
8	Adrar Tazaina	Tiourdiou	3.1
9	Adrar Tazaina	Amenzal	1.0
10	Aoulouss-2*	Tazzitount	4.8
11	Aoulouss-2*	Tourchit	1.9
12	Aoulouss-1**	Tazzitount	4.3
13	Aoulouss-1**	Tourchit	2.1

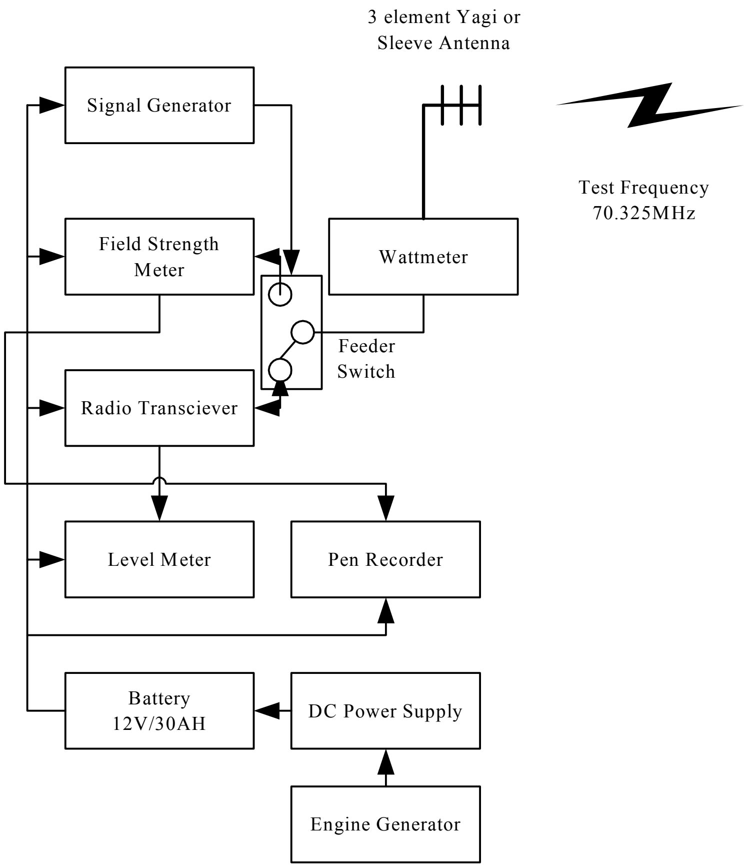
Note: For the Aoulouss Repeater Station, two candidate sites, Aoulouss-1 and Aoulouss-2 were employed. Aoulouss-1 is a small mountain peak (about 2,340m ASL) behind the Tourcht Station, and Aoulouss-2 is a small flat spot (about 2,200m ASL) about 1km down westward from Aoulouss-1.

(ii) Radio Frequencies

Three radio frequencies of 68.325, 70.325 and 72.325MHz were allocated especially for the propagation tests. These frequencies are a little lower than the 88MHz that was used for the circuit calculation. The small differences are not so significant for the radio propagation, although more diffractions effects are expected from the lower frequencies.

(iii) Equipment

A list of the test equipment is given in Table. 6.4.2, and their composition is illustrated in the following diagram:



Radio Propagation Test Diagram

(b) Test Result

Test results are summarized in Table 6.4.3 and Fig. 6.4.2. The same criteria as the circuit calculation are employed for the evaluation of the test spans, too.

All the spans except for the one between Agouns and Oukaimedan meet the ideal S/N and evaluated good for the data transmission. Especially, it is noteworthy that direct linkages of the two new repeater stations with DRHT Marrakech were justified by the tests. This allows establishment of a VHF radio network with the two stations not the three as shown in Fig. 6.4.3, leading to not only decrease of costs but also enhancement of the system reliability. Further discussions are made as follows:

(i) Aoulouss Repeater Site

Two candidate sites were conceived for the Aoulouss Repeater Station. Aoulouss-1 is a small mountain peak (about 2,340m ASL) behind the Tourcht Station, and Aoulouss-2 is a small flat spot (about 2,200m ASL) about 1km down westward from Aoulouss-1.

Aoulouss-2 is preferable as the repeater site, considering its easier accessibility. Unfortunately the span between DRHT Marrakech and Aoulouss-2 has only 17dB/μv of receiving strength, which is not enough. Aoulouss-1 that gives a sufficient value of 32 dB/μV is proposed as the site.

(ii) Relay of Agouns Station

Both the sites of Oukaimedan and Adrar Tazaina can relay the Agouns Station to DRHT Marrakech. Adrar Tazaina, which is almost directly seen from the Agouns Station even with unaided eyes, seems more preferable. With this selection of Adrar Tazaina as the repeater station for the Agouns Station, establishment of a radio network with two repeaters was made possible, excluding Okaimedan.

(iii) Radio Interference

During the propagation tests, no radio interferences by other communications were found at any test site on the three frequencies of 68.325, 70.325 and 72.325MHz.

(3) Radio Circuit Design for Telemetry System

Based on the results of the radio propagation tests, designing of the radio circuit network for the telemetry system was made as follows:

(a) Repeater Station

As explained in the previous subsection, two repeater stations of Adrar Tazaina and Aoulouss are incorporated into the radio network as shown in Fig. 6.4.3. This radial network is more advantageous in minimizing damages by troubles of the repeater stations than tandem connection of repeater stations

Proposed Two Repeater Stations

Station	Latitude	Longitude	Altitude	Accessibilité
Adrar Tazaina	N31°10.48’	W7°43.92’	3,010m	3 hours’ climbing from Amenzal Douar
Aoulouss	N31°15.12’	W7°38.75’	2,340m	1.5 hours’ mule riding and 0.5 hour climbing from Tourcht Douar

(b) Antenna Type

The repeater stations receive radio signal from 3 or four different directions. Hence, a non-directional antenna (Sleeve type) is applied. Broadband directional antenna (2 element Yagi type) is applied for all the flood watch station to avoid multi pass phase distortion. Difference of antenna gain shall be considered.

(c) Transmitter output power

10W of transmitter output power is a general standard for all the stations. For the Amenzal and Tourcht Stations that can expect strong receiving signal levels, 3W can be applied.

(d) Coaxial cable length

10m of coaxial cable were used for the propagation tests, but actual cable length of each station is different, depending on the site conditions. Difference of cable loss shall be considered.

(e) Antenna Mast Height

Height of the antenna masts for the tests was 10m. On the other hand, 7.4m high masts that are stored in a DRHT storage as spare parts of the Pilot Project Phase I are supposed to be used for the repeater and flood watch stations.

Influence of this introduction of the lower antenna masts is not significant for the repeater and flood watch station, but it decreases receiving signal levels of DRHT Marrakech to around 30dB/μV. Since DRHT Marrakech is a key station of the telemetry network, a 15m high antenna mast is specially proposed there to keep good propagation conditions,

After the above necessary adjustments and modifications, the signal to noise ratios (S/N) obtained in the field tests are corrected as follows:

Correction of S/N after Adjustments and Modifications

Station	Antenna type	Increase or decrease Antenna gain (dB)	Antenna height (m)	Coaxial cable length & additional loss	S/N obtained in Tests (dB)	Corrected S/N (dB)
Marrakech	2 element Yagi	2 → 6 = +4dB	10→15	30m 1.2-0.4 = -0.8dB	42.1	43.5
Aoulouss	Sleeve	2→ 2 = ±0dB	10→7.4	40m 1.6-0.4 = -1.2dB	42.1	43.5
Adrar Tazaina	Sleeve	2→2 = ±0dB	10→7.4	40m 1.6-0.4 = -1.2dB	43.0	43.5
Tiourdiou	2 element Yagi	8→6 = -2dB	10→7.4	15m 0.6-0.4 = -0.2dB	42.1	42.0
Amenzal	2 element Yagi	8→6 = -2dB	10→7.4	15m 0.6-0.4 = -0.2dB	42.8	42.0
Tazzitount	2 element Yagi	8→6 = -2dB	10→7.4	15m 0.6-0.4 = -0.2dB	43.0	43.0
Tourcht	2 element Yagi	8→6 = -2dB	10→7.4	15m 0.6-0.4 = -0.2dB	42.8	43.0
Agouns	2 element Yagi	8→6 = -2dB	10→7.4	15m 0.6-0.4 = -0.2dB	40.8	43.0

The corrected S/N data would be used for reference when radio equipment are installed actually at the sites.

6.4.2 Specifications and Configuration of Equipment

Following the determination of the telemetry network, specifications of the Pilot Project Phase-II that is be installed in 2003 are briefly described in this section. Detailed specifications of the major equipment for the Pilot Project Phase-II are given in the Volume 3, Supporting Report Appendix I: Telemetry and Warning System.

(1) Required Functions

Two main functions will be added to the semi-automatic system established in the first stage of the Pilot Project. The first one is an automatic real-time data transmission system that upgrades the existing semi-automatic system into a fully automatic telemetry system. The second one is a selective calling function for the radiotelephone network among Al Haouz Province, Ourika Caidat and the Iraghf Warning Post, which is expected to ensure prompt and accurate communication during a flood time including dissemination of flood warnings. The conceptual system diagram of the total Pilot Project is illustrated in Fig. 6.3.1.

(a) Automatic Real-time Data Transmission

A fully automatic telemetry system is realized with establishment of the automatic real-time data transmission system. Hydrological data observed automatically at the five flood watch stations are automatically transmitted to the Master Information Center at DRHT on real-time basis. The existing manual operations of verbal data transmission through the radiotelephones and data keying-in through the client PC will be replaced by the telemetry system, but will be left as a back-up system.

For this additional function, VHF radio equipment is installed at the flood watch stations, two repeater stations are newly built on the mountain tops of Adrar Tazaina and Aoulouss, and a telemetry supervisory and control system is incorporated to the Master Information Center.

Details of the transmission system is explained as follows:

(i) Data Transmission Protocol

A Japanese data transmission protocol established by Ministry of Land, Transportation and Infrastructure of Japan is employed for the data transmission system.

(ii) Calling method

The telemetry supervisory and control system of the Master Information Center can calls the flood watch stations in different three modes to collect observed rainfall and/or water level data. The flood watch stations are to automatically return the hydrological data immediately after called by the supervisory and control system.

1) Automatic calling mode

In the automatic calling mode all the five flood stations are called automatically under control of a system time of the telemetry supervisory and control system. The calling interval is 10, 30 or 60 minutes. This automatic calling mode has priority over the other modes.

2) Manual calling mode

In the manual calling mode an operator can call manually all the stations or a selected station whenever he wants.

3) Re-calling mode

In case no response or wrong data are received from any of the flood watch stations, re-calling is made one time automatically.

(iii) Event-reporting function

The flood watch stations have an event-reporting function that enable the stations to report occurrence of pre-defined events automatically to the telemetry supervisory and control systems:

- Detection of rainfall (1 mm rainfall tip of rain gauge)
- Detection of water level rise up to the pre-alert water level

Receiving the event-reporting signal from any one of the flood watch stations, the telemetry supervisory and control system is to call all the flood watch stations automatically.

(iv) Response method

The flood watch stations return digital hydrological data to the telemetry supervisory and control system when called.

(v) Telemetry Radio Network

To ensure stable communication quality between the Master Information Center at Marrakech and the five flood watch stations, two repeater stations are to newly be built on the mountain tops of Adar Tazaina and Aoulouss. The Adar Tazaina Station relays three flood watch stations of Agouns, Tiourdiou and Amenzal. The Aoulouss Station relays two flood watch stations of Tourcht and Tazzitount.

(b) Selective Call System for Waning Dissemination

To ensure prompt and accurate communication during a flood time including dissemination of flood warnings, a selective call system is introduced to the VHF radiotelephone network among the Province, Ourika Caidat and the Iraghf Warning Post. This selective call system enables closed communication among the three, separated from other stations linked in the same existing provincial network. The selective call system has a siren too that can alarm operators/guardians of an emergency call.

A new radiotelephone unit with the selective call system is additionally installed at the monitoring stations of Al Haouz Province and Ourika Caidat respectively in 2003. The selective call system is incorporated to the existing radiotelephone installed at the warning post in 2001. In principle these radiotelephones are used exclusively for the communication among the three.

(2) Specifications of Equipment

Specifications of equipment for the Pilot Project Phase-II are determined to meet the above requirements, as follows:

(a) General Conditions

(i) Ambient Conditions

All the equipment and materials shall be operational and/or durable under the following ambient conditions:

Ambient Conditions

Items	Outdoor Equipment	Indoor Equipment	Personal Computers and Peripherals
Temperature	-15°C to 50°C	10°C to 40°C	15°C to 35°C
Relative humidity	90 % or less	20% to 80% non-condensing	20% to 80% non-condensing
Withstand wind speed	50m/sec.	N/a.	N/a.
Location of Installation	460m to 3,200m above sea level	460m to 3,200m above sea level	460m above sea level

(ii) Power Consumption

All the equipment shall be of low power consumption, power-saving type, and meet capacities of the existing power supply units.

(iii) VHF Radio Frequency Assignment

Frequency band of 68 to 75MHz is employed for the telemetry system and 150MHz for the new radiotelephones of the provincial warning network.

(b) Description of Equipment by Station

Configurations of equipment of the Master Information Center, the flood watch stations and the two new repeater stations are illustrated in Figs. 6.3.2, 6.3.3 and 6.4.4 respectively. Block diagrams of radio equipment for Ourika Caidat, Al Haouz Province and the Iraghf Warning Post are also presented in Figs. 6.3.4. In these figures, new equipment to be installed in 2003 are painted in gray.

Configuration of equipment for each station is summarized as follows:

(a) Master Information Canter at DRHT (ABHT)

For the Master Information Center at DRHT, the telemetry supervisory and control equipment, a telemetry operation PC with display and control software, an UPS, DC power supply equipment, VHF radio equipment, an antenna system and a data processing subsystem are installed to collect hydrological data from the flood watch stations and to incorporate them into the existing data processing system automatically on real-time basis, as shown in Fig. 6.3.2.

A 15m tall antenna mast, at the top of which a 2 element Yagi antenna is installed, will be built in the garden of DRHT. The telemetry supervisory and control equipment are put in a hanging type cabinet together with the radio unit. Control of the telemetry supervisory and control equipment is made through the telemetry operating PC, and collected hydrological data are transmitted to the data process server through the communication control unit (CCU).

(b) Flood Watch Stations

A 7.4m tall antenna mast at the top of which a 2 element Yagi antenna is installed, is built at the side of every station house. A new VHF radio unit is installed in and incorporated to the existing remote terminal unit (RTU). Configuration of the equipment are given in illustrated in Fig. 6.3.3(1/4) for the Agouns and Tourcht Stations, in Fig. 6.3.3(2/4 and 3/4) for the Amenzal and Tiourdiou Station and in Fig. 6.3.3(4/4) for the Tazzitount Station.

(c) Repeater Stations

Two new VHF to VHF repeater stations is built in 2002. The Adrar Tazaina Repeater Station that is created on the top of a 3,010m high mountain behind the Amenzal Station relays the Amenzal, Agouns and Tiourdiou Stations to DRHT in Marrakech. The Aoulouss Repeater Station that is created in the top of a 2,340m high mountain behind the Tourcht Station relays the Tourcht and Tazzitount Repeater Stations to DRHT.

Two 7.4m tall antenna masts are built for transmission and receiving antennas at the side of a 3mx 3m station house that is to be created in the Pilot Project (Phase II) too. A sleeve antenna is attached on the top of each mast. Repeater equipment are put in a cabinet together with two sets of VHF radio units. A power supply unit consisting of solar cells, a power distribution board and sealed lead-acid batteries are also provided. A block diagram of the repeater stations is presented in Fig. 6.4.4.

(d) Iraghf Warning Post, Caidat and Province

For the Iraghf Warning Post, a 5-tone selective calling unit and a siren unit are incorporated to the ICOM-made radio installed in the first phase as shown in Fig. 6.3.4 (1/3).

A 23 m tall antenna mast ,at the top of which a 3-element Yagi antenna is fixed, is built in the compound of the Ourika Caidat building. A new VHF radiotelephone with a 5-tone selective calling unit and a siren unit are installed in the monitoring station room. A power supply unit consisting of a battery charger and lead acid batteries will be also provided as shown in Fig. 6.3.4(2/3).

As for Al Haouz Province, the existing antenna mast on the roof of the office building is used to fix a new 3-element Yagi anntena. A new VHF radiotelephone with a 5-tone selective calling unit and a siren unit is installed in the monitoring station room. An AC power supply unit is also provided as shown in Fig. 6.3.4(3/3).

CHAPTER 7. IMPLEMENTATION AND EXPERIMENTAL OPERATION OF PILOT PROJECT PHASE-I

7.1 Implementation Work

As described in Chapter 6, the Pilot Project is implemented step-wisely between 2001 and 2003. The implementation work of the first phase, which was mainly composed of facility construction, installation of equipment and software, and development of a flood forecasting program, was commenced in July 2001 and completed in December 2002, as shown in Table 6.2.1.

Prior to the installation of equipment, the construction work of FFWS facilities was commenced in July 2001. The equipment and materials for the Pilot Project arrived at Casablanca Port on 20 October 2001, immediately followed by the installation work. The installation work that started with flood watch stations in the mountain areas was completed in the beginning of December 2001. The programming for flood forecasting was also made in line with the progress of the installation work.

7.1.1 Construction Work

Two water level gauge equipment houses, three water level gauge supporting masts, fourteen metal poles and ten concrete platforms were constructed by a local contractor in the Pilot Project. It is noted that DRHT also built a warning post house at Iraghf and a station house at Agouns as their undertakings for the Pilot Project.

Constructed Facilities

Facility	Quantity	Location
Water Level Gauge Equipment House	2	Amenzal and Tiourdiou
Water Level Gauge Supporting mast	3	Amenzal, Tiourdiou and Tazzitount
Metal Pole (Panzermast) for cable suspension	14	Tazzitount(3) and Iragfh(11)
Concrete Platforms for Solar Panels and Rainfall Gauges	10	Amenzal, Tiourdiou, Tourcht, and Tazzitount

(1) Water Level Gauge Equipment House

An equipment house with an inner space of 1 m (W) x 2.5 m (L) x 2.1 m (H) was built for both the two separate-type water level stations, Amenzal and Tiourdiou. A net fence was provided to the roof of the house at Tiourdiou to protect solar panels installed there from falling stones.

(2) Water Level Gauge Supporting Mast

A supporting mast for the ultrasonic water level gauge, of which drawing is presented in Fig. 7.1.1, was built at the three stations, Amenzal, Tiourdiou and Tazzitount. The height of the masts is different depending upon the site conditions, namely 3.0 m for Amenzal, 4.0 m for Tiourdiou and 5.3 m for Tazzitount. The lowest parts of the masts for Tiourdiou and Tazzitount were protected from flowing rocks and stones with a concrete block.

(3) Metal Pole (Panzermast)

Total 14 metal poles that were delivered together with the other equipment and materials from Japan were built in Tazzitount and Iraghf. The 11 poles are for stringing a signal cable for the laud-speakers of the Iraghf Warning Post, and the rests are for stinging a signal cable for the ultrasonic gauge at Tazzitount. An illustration of the pole installation is presented in Fig. 7.1.2.

(4) Concrete Platform for Solar Panels and Rainfall Gauge

Total 10 concrete platforms, on which solar panels or rainfall gauges were placed, were made on the roofs of the water level gauge equipment houses and the flood watch stations. A special attention was paid to the directions of these platforms so that the solar panels face the south at the right angle.

7.1.2 Installation of Equipment and Software

The installation work was done by a local agent under the supervision of three Japanese engineers of Japan Radio Co., Ltd., the supplier of the equipment and materials.

The local agent and the Japanese engineers formed three teams. Teams A and B are those for installation of equipment, and Team C is for software installation. Each team is composed of a Japanese engineer as a chief, two or three employees of the local agent and a DRHT technician as an OJT (On the Job Trainee).

An inventory list of the equipment and a detailed installation schedule are given in Tables 7.1.1 and 7.1.2 respectively. Photographs of the installation work are also compiled in an album in Volume 4 Data Book. Moreover, examples of the graphic information to be created and distributed to the monitoring stations by the data processing system of the Master information Center at DRHT are given in Fig. 7.1.3.

7.1.3 Development of Flood Forecasting Program

A flood forecasting program based on the USSCS Method and Muskingum Method was developed and installed in the client personal computer by a local consultant company under the supervision of the Study Team. Examples of simulation results are presented in Fig. 7.1.4.

7.2 Preparation of Guidelines

Following the installation work, organization concerned commenced an experimental operation gradually with the newly provided equipment. To assist the organizations to operate the total system more systematically, new guidelines were proposed in this section by remaking those for the draft master plan presented in Subsection 5.6.2. The original guidelines for the Master Plan were modified and concretely developed into those for the Pilot Project Phase I.

As stressed in Subsection 6.2.1, the Pilot Project is still half way on the way to the Master Plan. Compared with the Master Plan, the Pilot Project is still premature in terms of the covering area, accuracy of forecasting and rapidness of system operation. Similarly, the new guidelines that were elaborated based on limited available information are also still tentative and need to be updated in future. Many inconveniences, which will be precious lessons for the updating, may arise in the course of the experimental operation.

Major modifications from the original guidelines are:

- The target area is limitted to the Ourika River Basin, especially the Iraghf area where a warning post was created in the Pilot Project.
- Since the established system is still ineffective against debris flows from the tributaries, such debris flows are excluded from objective disasters that the system must deal with. Only river

flood is considered as an objective disaster type. Therefore, flood notices by DRHT and flood warnings by the Province described in the new guidelines are all regarding river floods.

- The pre-alert and alert levels of rainfall and water level that are indicators calling for anti-flood actions of organizations concerned were concretely set based on scarece hydrological records. These levels are tentative ones and should be updated after a certain quantity of hydrological data is accumulated.

- The new guidelines are based on the provisional semi-automatic system before the automatic data transmission system is additonally introduced in 2003. Voice communication for data transmission between the flood watch stations and DRHT, and keying-in of collected data to the data processing system, which will be replaced by the automatic system are still employed in the semi-automatic system. These parts in the guidelines regarding the semi-automatic system should be updated under the Pilot Project Phase-II.

7.2.1 Principal Organizations and General Procedures

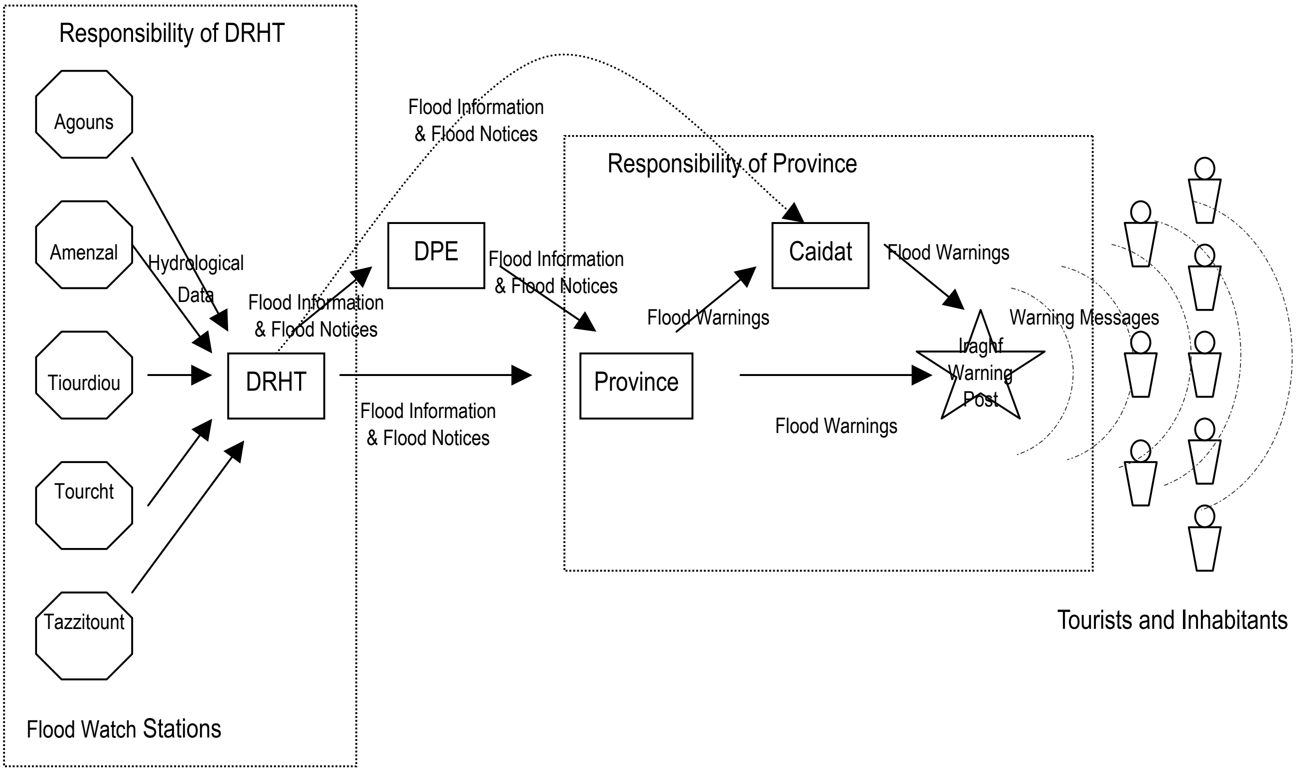
Among many organizations directly or indirectly involved in the FFWS operation, DRHT, DPE Al Haouz, Al Haouz Province are considered as the principal organizations that play key roles in the Ourika River Basin FFWS operation. In particular, the roles of DRHT and the Province are very significant for actual operation of the FFWS in the Ourika River Basin.

DRHT is a technical organization who is responsible for distribution of flood information and flood notices to the other organizations concerned. DRHT collects hydrological data from the flood watch stations, processes them into visualized information and distribute the processed information to DGH, DPE, the Province and Ourika Caidat through the dial-up computer network. Flood Forecasting is an important task for DRHT. Once the situation is anticipated to worsen so badly, DRHT announce Flood Notices to call for necessary actions of the organizations concerned.

DPE is regarded as a representative of the Ministry of Equipment in the Province. DPE generally plays a role of interface between DRHT and the Province. However, DRHT is allowed to directly contact the Province in an emergency case such as a flood disaster. On the other hand, DPE has a road maintenance brigade stationed at Oukaimedan. Since the brigade has a vehicle equipped with a VHF radiotelephone, the brigade could be an additional information source during a flood.

The Province is responsible for issuance and dissemination of Flood Warnings. It is the governor that decides to issue Flood Warnings based on the flood information and Flood Notices provided by DRHT. The Flood Warnings are disseminated directly or indirectly through the Ourika Caidat to the Iraghf Warning Post, where warning messages are broadcast for tourists and inhabitants.

7.2.2 Definition of Flood Notices, Flood Warnings and Flood Phases



General Procedure of Ourika River Basin FFWS

To ensure prompt and appropriate actions of the organizations concerned, Flood Notices, Flood Warnings, and Flood Phases are defined concretely for the Ourika River Basin.

(1) Flood Notices by DRHT (ABHT)

Flood Notices are interpreted information on the flood situation by DRHT and calls for necessary actions of the organizations concerned.

(a) Definition of Flood Notices

Three kinds of Flood Notices are defined generally for each of a river flood and a debris flow, but only those for a river flood are applied for the Pilot Project. They are Pre River Flood Notice, River Flood Notice, Cancellation of Flood Notice(s).

Observed rainfall or water level data at the five flood watch stations are used as objective measures for defining the Flood Notices. The observed data are compared with pre-defined Pre-alert and Alert levels of rainfalls and water levels at the stations, as follows:

(i) Pre River Flood Notice

This is to notify the organizations concerned that rainfall or water level has exceeded the Pre-Alert Level at any flood watch station and the flood is anticipated to further develop.

(ii) River Flood Notice

This is to notify the organizations concerned that rainfall or water level has exceeded the Alert Level at any flood watch station and the situation is anticipated to become so bad that a flood disaster including losses of human lives might take places soon.

(iii) Cancellation of Flood Notice(s)

This is to notify the organizations concerned that rainfall or water level has decreased below the Pre-Alert Level at all the flood watch stations and the flood risk has gone away.

(b) Determination of Pre-Alert and Alert Levels of Rainfall and Water Level

Pre-Alert and Alert Levels of rainfall and water level are regarded as indicators of seriousness of the flood situation. According to the above definitions of the Flood Notices, the Alert Level is considered the minimum level that might cause flood damages including loss of human lives. On the other hand, the Pre-alert Level is considered the minimum level in which a symptom of the growing flood can be narrowly recognized.

Generally determination of these levels must be made through a close examination of records of hydrology and actual responses of the organizations concerned during past floods. Unfortunately, such records are still scarce in the Ourika River Basin, where frequent hydrological observation with an interval of an hour or 10 minutes that could reveal characteristics of a typical flash flood in the Ourika River has just started in the Pilot Project.

Making a full use of limited available hydrological information, the Pre-alert and Alert Levels of rainfall and water level at the five flood watch stations are tentatively proposed hereinafter:

(i) Alert Level

According to the hydraulic simulation presented in the Interim Report 2 as shown in Fig 7.2.1, the flow capacity around the Iraghf area is as small as 160 m3/s, corresponding to 3 years of return period. This 3-year return period is applied for the Alert Levels of rainfall and water level at the five stations.

Discharges of the 3-year return period at the Amenzal, Tiourdiou and Tazzitot are estimated by using Creager's curves, and then converted to corresponding water levels based on the rating curves constructed by Manning's formula. The Creager's curves of six different return periods and the rating curves at the three water level stations are presented in Figs. 7.2.2 and 7.2.3.

Since two intervals of 10 minutes and 60 minutes are selectively employed for the data collection from the flood watch stations according to development of the flood situation, alert rainfall intensities of the two durations should be determined. 5 mm/10minutes and 20 mm/60minutes, which are 3-year rainfall intensities of 10 minute and an hour durations estimated at the Aghbalau Station, are applied for all the five flood watch stations.

Alert Water Level and Rainfall Intensities

Station	Discharge (m3/s)	Water Level (cm)	Rainfall Intensity (mm)	
			10 min. Rainfall	60 min.Rainfall
Agouns	N/a	N/a	6	20
Amenzal	50	1,170 (1,155)	6	20
Tiourdiou	100	405	6	20
Tourcht	N/a	N/a	6	20
Tazzitount	160	450	6	20

Note: Values in parentheses are old values before the revision in August 2003.

(ii) Pre Alert Level

The Pre-alert level is a very important indicator for announcement of the Pre River Flood Notice. As explained in (3) Flood Phase of this subsection, the Pre River Notice triggers the Flood Watch Phase when all the related organizations must stand by against the probable growing flood. Therefore, the Pre Alert Level is regarded as the minimum level for initiating actions of the organizations concerned against the flood.

On the other hand, it is very difficult to determine this Pre-alert level. If it is set lower, the low Alert-level forces the organizations concerned to initiate their actions so frequently. If set higher, they are not allowed to have a long time margin for transferring from the Flood Watch Phase to the Evacuation Phase. Generally it should be determined through compromise between hydrological requirement and capacities of the organizations.

In this Pilot Project, values of water level and rainfall at the Pre-Alert Level are tentatively proposed at 25 to 50% of those for the Alert Level. The experimental operation of the Pilot Project could be commenced with these values, which are to be updated after a certain quantity of records is accumulated. The Pre-alert water levels are drawn on the cross section profiles together with their Alert water levels as given in Fig. 7.2.4.

Pre-Alert Water Level and Rainfall Intensities

Station	Discharge (m3/s)	Water Level (cm)	Rainfall Intensity (mm)	
			10 min. Rainfall	60 min. Rainfall
Agouns	N/a	N/a	3 (2)	10 (5)
Amenzal	13	1,130 (1,095)	3 (2)	10 (5)
Tiourdiou	25	340	3 (2)	10 (5)
Tourcht	N/a	N/a	3 (2)	10 (5)
Tazzitount	40	365	3 (2)	10 (5)

Note: Values in parentheses are old values before the revision in August 2003.

To know how long time margin this 25% can allow the organizations concerned, discharge records at the Agbalau Station were examined. The following table presents time that it took for the river discharge to increase from $50m^3/s$ to $200m^3/s$ during past major floods at the Agbalau Station, where $200m^3/s$ and $50m^3/s$ are corresponding to the 3-year discharge and its 25% respectively. As seen in the hydrographs of Fig. 7.2.5, some floods devolved very slowly and gradually but others suddenly and sharply. The time margin also varied very much from 2 to 3minutes of the 1995 flood to 7,680minutes of the 26 October to 2 November 1987 Flood.

Comparison of Rapidness of
Discharge Increase at Agbalau Station

Flood Period	Peak discharge (m3/s)	Time from 50 m^3/s to 200 m^3/s (min.)
8 to 9 Sep. '79	350	90
11 Feb. '87	250	360
26 Oct. to 2 Nov. '87	651	7,680
14 Jul. '89	823	180
10 Mar. '90	265	180
14 Sep. '90	207	50
5 to 7 Dec. '91	200	2,040
1 Aug. '92	290	80
17 Aug. '95	1,030	2 to 3
28 Oct. '99	762	170

(c) Distribution of Flood Notices

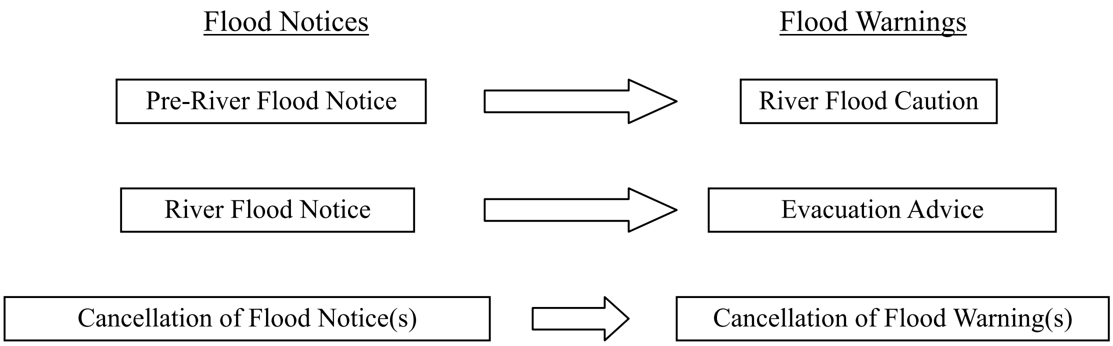
Al Haouz Province, Ourika Caidat, DPE, DGH and DMN Marrakech are considered as recipients of the Flood Notices. To keep a record of the distribution of the Notices, the Flood Notices are in principle sent in a fax letter, of which a sample form is given in Fig 7.2.6. Moreover, a telephone call also should be made at the four monitoring stations, Al Haouz Province, Ourika Caidat, DPE and DGH to confirm their reception of the Notice and advise them to access the Master Information Center of DRHT through the dial-up computer network for sharing flood information.

(2) Flood Warnings by Province

Based on collected flood information including the flood notices announced by DRHT, the Governor finally issues the Flood Warnings, which inhabitants and tourists are advised to follow.

Three kinds of flood warnings have been defined for the Ourika River Basin. They are River Flood Caution, Evacuation Advice, Cancellation of Flood Warning(s), depending of the flood situation.

The decision for the warning issuance must be made appropriately and promptly even when the Governor is absent. To help the governor or his substitute, the Flood Notices announced by DRHT are connected to the Flood Warnings as follows:



Relation between Flood Notices and Warnings

(a) Definitions of Flood Warnings

(i) River Flood Caution

River Flood Caution is to warn personnel of organizations concerned, inhabitants and tourists that a river flood is anticipated soon, and to call for their preparation for evacuation. Once a Pre-River Flood Notice has been announced by DRHT, the governor is advised to issue a River Flood Caution.

(ii) Evacuation Advice

Evacuation Advice is to advise inhabitants and tourists to evacuate themselves to designated evacuation places in accordance with an evacuation plan. Evacuation Advice is also disseminated to personnel of organizations concerned to call for their assistance for the evacuation and preparation for rescue operations. Once a River Flood Notice has been announced, the governor is advised to issue an Evacuation Advice.

(iii) Cancellation of Flood Warning(s)

Cancellation of Evacuation is to notice inhabitants and tourists as well as personnel of organizations concerned that the flood warning(s), namely the Evacuation Advice and/or River Flood Caution has (or have) been cancelled. Once the flood notice(s) has or (have) been cancelled by DRHT, the governor is advised to issue a Cancellation of Flood warning(s).

(d) Dissemination of Flood Warnings

(i) To Inhabitants and Tourists

The Flood Warnings are disseminated to inhabitants and tourists around the Iraghf Warning Post through the Ourika Caidat and the warning station. Once the warning post has been informed of issuance of a flood warning by the Ourika Caidat through the province’s VHF radiotelephone network, the warning post is to broadcast a corresponding warning messages over the flood prone area.

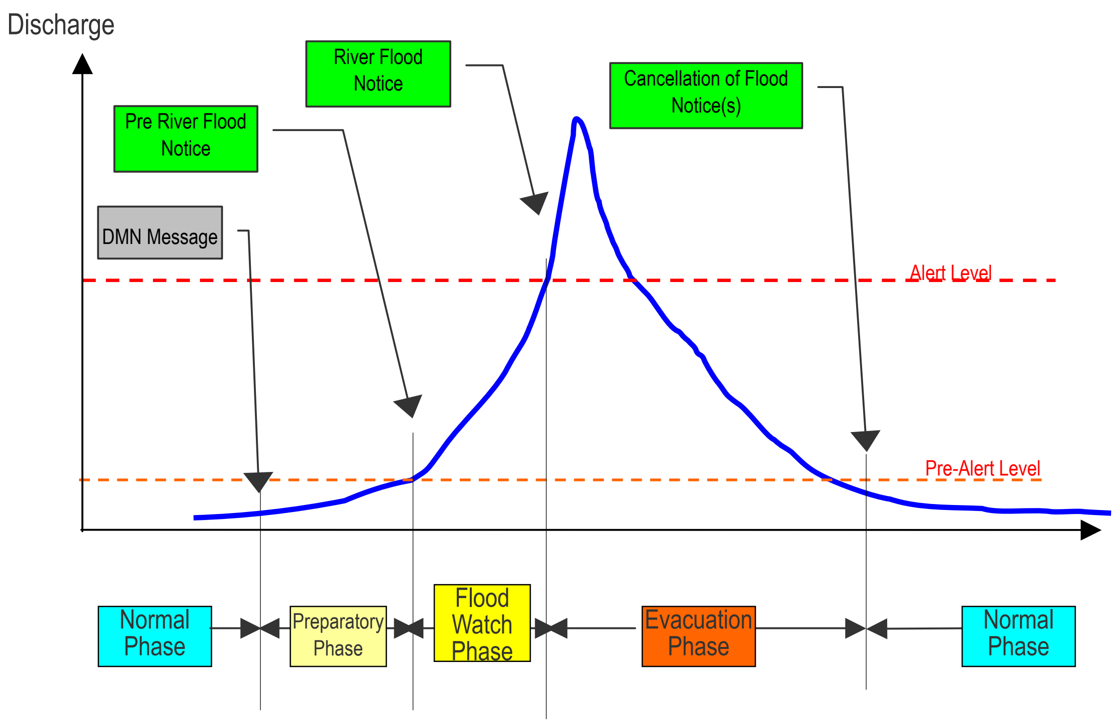
(ii) To Organizations Concerned

The flood warnings should be disseminated from the Province to other organizations concerned such as Royal Mounted Police, Civil Protection, Ministry of Interior, and other organizations involved in the ORSEC Plan. To keep a record of the dissemination, the flood warnings should be in principle sent in a fax letter, of which a sample form is given in Fig 7.2.7.

(3) Flood Phase

A flood period is divided into four Flood Phases, namely Normal Phase, Preparatory Phase, Flood Watch Phase and Evacuation Phase in an order of seriousness of the flood situation. The principal organizations, DRHT, DPE Al Haouz, Al Haouz Province are required to take appropriate actions in accordance with the operation procedures stipulated for each of the Flood Phases in the next sub-section.

The DMN Pre-alert and Alert Messages and the DRHT flood notices are used for transition from one phase to another as explained below:



Division of Flood Period into Four Flood Phases

(a) Normal Phase

The Normal Phase is a pre-flood period or a post-flood period when no danger of a flood is anticipated at all.

Once a Pre-alert Message or an Alert Message has been announced by DMN during this phase over the Ourika area, the Normal Phase terminates and the Preparatory Phase commences. Once a Pre River Flood Notice has been announced by DRHT during the Normal Phase, the Flood Watch Phase breaks directly.

(b) Preparatory Phase

The Preparatory Phase is a period when the organizations concerned must be alert to a probable rainstorm although actual symptoms of the storm have not been detected yet.

Once a Pre River Flood Notice has been announced by DRHT during the Preparatory Phase, the Preparatory Phase terminates and the Flood Watch Phase commences. The Preparatory Phase terminates with expiration of the DMN messages, and then the Normal Phase resumes.

(c) Flood Watch Phase

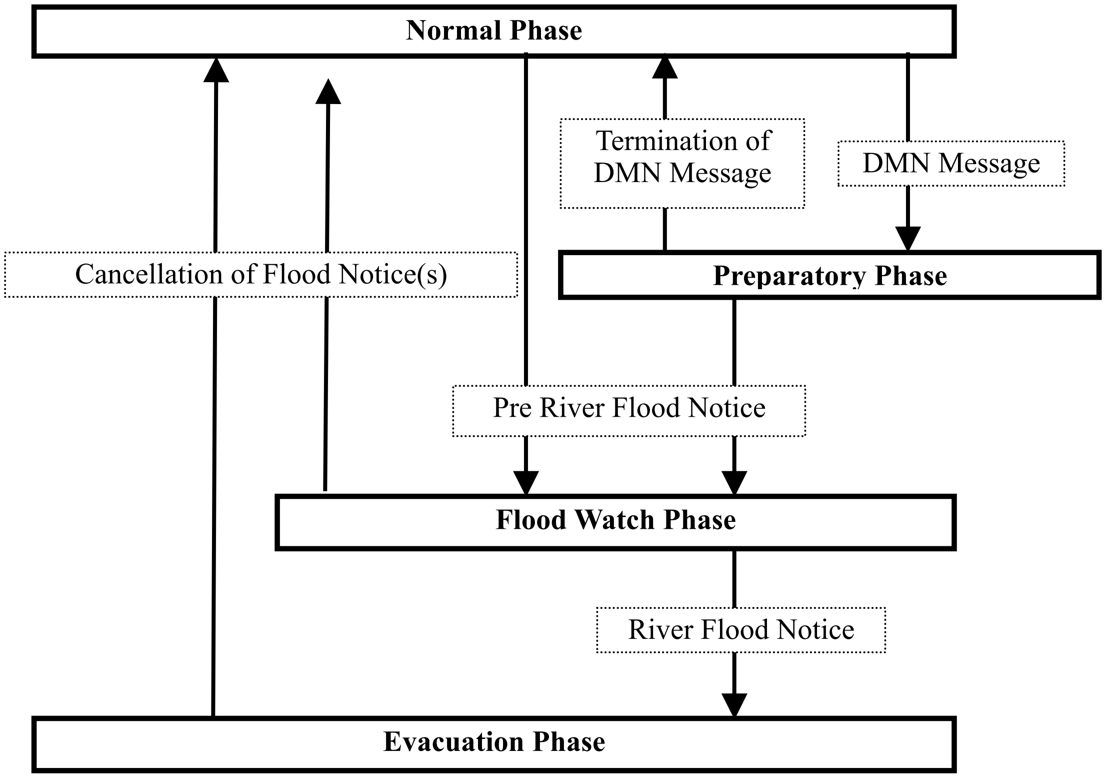
The Flood Watch Phase is a period when the situation has worsened or is expected to worsen so badly that some symptoms of a flood such as intensive rainfall and/or swelling of river water has appeared actually.

Once a River Flood Notice has been announced by DRHT during this phase, the Flood Watch Phase terminates and the Evacuation Phase commences. Once the flood situation has settled much enough for DRHT to cancel the Pre-River Flood Notice, the Flood Watch Phase terminates and the Normal Phase resumes on the other hand.

(d) Evacuation Phase

The Evacuation Phase is a period when the flood situation has been worsened so badly that evacuation is necessary.

Once the flood situation has settled in this phase much enough for DRHT to cancel the flood notices, the Evacuation Phase terminates and the Normal Phase resumes.



Transition of Flood Phase and Flood Notices

7.2.3 Actions and Procedures to be Taken by Principal Organizations

Following the definitions of the Flood Phases, concrete actions and procedures to be taken by the principle organizations, namely DRHT, DPE Al Haouz and Al Haouz Province are examined and compiled in Table 7.2.1. Summaries of the guidelines are described as follows:

(1) FFWS Operation during Normal Phase

In this phase no immediate actions are generally needed except for DRHT who must detect any subtle symptom of a storm including DMN messages at any time, but the other organizations also must keep on duty 24 hours even in this Normal Phase to enable their quick response to any change of the situation.

(a) Detection of Flood Symptom by Flood Watch Station

In the semi-automatic system where automatic data transmission system has not been established, roles of the guardians of the flood watch stations are still very important. They are usually required to report the weather conditions, rainfall and water level data to DRHT four times a day at 7, 11, 15 and 17 o'clock everyday. In case any symptom of a flood including commencement of rainfall and rise of water level is detected at the stations, they are to immediately inform DRHT of it and to start close watching and reporting of rainfall and/or water level.

The warning post and the DPE's Oukaimedan brigade can be also the first detector of a flood. They are also required to inform their superior organizations, Ourika Caidat for the warning post and DPE headquater in Tahanaout of such symptoms.

(b) Regular Communication between Caidat and Warning Post

Similar to DRHT, Ourika Caidat also should receive a report from the warning post everyday. Three times a day at 11, 15 and 17 o'clock the guardian are required to report about conditions of the weather, river conditions and tourists to Ourika Caidat through the VHF radiotelephone. This routine communication might be useful to check the condition of the radiotelephone and not to bore the guardian of the warning post.

(c) Maintenance of Equipment

Maintenance of equipment is also very important in this phase to ensure correct functions of the FFWS equipment during flood times. The maintenance work may be generally divided into two kinds, namely preventive maintenance and correction maintenance as explained in Subsection 4.2.1.

(d) Execution of Simulation Drill and Updating of Guidelines

The principal organizations, DRHT, DPE and the Province shall gather to have a meeting for updating of the operation guidelines, and to discuss on a joint simulation drill in May or June, gathering representatives from the stations/posts and the organizations concerned. The joint drill involving all the principal organizations shall be made under collaboration of Royal Mounted Police in June, just before the tourist season. Before the joint drill, every organization must conduct an internal FFWS operation drill once a year al least to remind all the personnel concerned of the FFWS operation procedures. After every flood that reached the Flood Watch Phase or further and every joint drill, all the principal organizations should meet after compiling each evaluation report on its FFWS operation, which is to be referred to for updating of the operation guidelines.

(2) FFWS Operation during Preparatory Phase

The most important thing during this phase is to get ready against a growing flood. A FFWS operation team consisting of an engineer at least and a few technicians shall be organized in DRHT as soon as this Preparatory Phase has commenced.

The guardians of the flood watch stations, the technicians of the DPE brigade posts and the guardian of the warning post also must stand by under the guidance of their superior organizations, DRHT, the DPE Headquarters or Ourika Caidat.

(3) FFWS Operation during Flood Watch Phase

The Flood Watch Phase is a period when the flood situation has been worsened so badly that some symptoms of a flood such as heavy rainfall and swelling of river water have appeared actually.

The flood phase often jumps to the Flood Watch Phase directly from the Normal Phase due to sudden development of a rainstorm that even DMN missed. In this case all the organizations are required to take necessary actions urgently to get ready for further development of the flood situation. In particular, DRHT must organize a FFWS operation team immediately after the announcement of the Pre Flood Notice, to follow up the changing flood situation.

The Province can issue a River Flood Caution and order the warning post to broadcast a River Flood Caution message over the flood prone area.

(4) FFWS Operation during Evacuation Phase

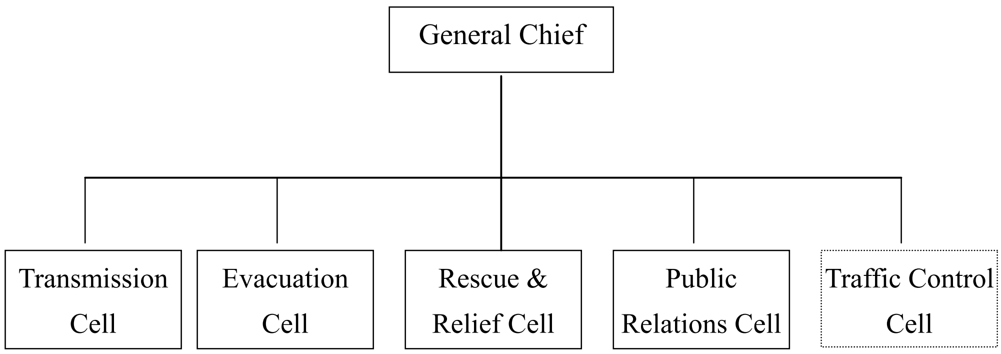
The Evacuation Phase is an emergent period when the flood situation has been worsened so badly that inhabitants and tourists are advised to immediately escape to safer places. Prompt issuance and dissemination of Evacuation Advice is the most important during this phase.

7.2.4 Guidelines of Evacuation Activities

Guidelines of evacuation activities are prepared in this section, concentrating on the Iraghf area where a warning post was installed in the Pilot Project. General concepts for the guidelines are the same as those for the Master Plan proposed in the Interim Report 2, although small modifications were made by specifying the evacuation organization and evacuation places.

(1) Set-up of Evacuation Organization

An evacuation organization must be formed among inhabitants for the Iraghf area. The evacuation organization is responsible for all activities related to evacuation under the guidance of the Province. The evacuation organization may be generally composed of five cells under a general chief who supervises all the cells. They are cells for transmission, evacuation, rescue and relief, public relation and traffic control. However, the traffic control might be beyond



Organization Structure of Evacuation Organization

capacities of the inhabitants who have never been legally authorized to do so.

Each cell is composed of a cell chief and some members who are selected among inhabitants in consultation of the rural commune and Ourika Caidat. However, a chief and members of the tourists-guiding cell are selected among employers and employees of tourism industries such as hotels and restaurants. Responsibilities of each cell section are given in the following table:

Members of Evacuation Organization

Cell	Main Responsibilities
General Chief	Representing the evacuation organization and supervising all cells.
Transmission	Operation and maintenance of the warning post.
Evacuation	Guiding inhabitants and tourists to designated evacuation places.
Rescue & Relief	Rescue and relief activities
Public Relations	Public relations on FFWS
Traffic Control	Control of tourist cars during flood times

(1) Operation of Warning Post

Two guardians of the Iraghf Warning Post were nominated from the Setti Fadma Rural Commune. The two guardians are supposed to stand by for 24 hours in the warning post in two shifts against a sudden development of a flood.

As described in Table 7.2.1, the guardians shall report weather and river conditions to Ourika Caidat three times a day. In flood times during a flood phase and an evacuation phase, they must keep in contact with Ourika Caidat by radiotelephone to exchange flood information. Once a flood warning is issued, they are directed to broadcast over the flood areas a relevant warning message which have been recorded in a cassette tape in four different languages, Arabic, French, Berber and English. Moreover, they must patrol over the Iraghf area if directed by Ourika Caidat.

Warning Message

Flood Warning	Warning Message
River Flood Caution	This is the Iraghf Warning Post. Please be informed of a River Flood Caution issued by the Al Haouz Province. Heavy rainfall and/or water level rising are being observed in the upstream of the Ourika River. You are advised to get prepared against further development of the flood and to pay attention to the next broadcast from this warning post.
Evacuation Advice	This is the Iraghf Warning Post. Please be informed of an Evacuation Advice issued by the Al Haouz Province. The flood is further developing into a dangerous level in the upstream. You are advised to evacuate yourself to safer places and to pay attention to the next broadcast from this warning post.
Cancellation of Flood Warning(s)	This is the Iraghf Warning Post. Please be informed that the Al Haouz Province has cancelled the flood warning(s). The flood risk has passed and the river has settled to normal conditions. Thank you very much for your attention.

(2) Designation of Evacuation Places and Routes

A flood inundation area map has been elaborated as shown in Fig. 7.2.8 for the Iraghf Area in this Study, based on the hydraulic analysis presented in the Interim Report 2 and the site reconnaissance.

This map shows not only inundation areas with a return period of 100 years but also two safer places as evacuation places. As revealed in the Interim Report 2, it is very difficult to find safe places in and around the Iraghf area where all kinds of disasters including floods, debris flows, falling rocks, land slides and slope failures can possibly take place. These two safer places, which might be still under a threat of secondary disasters, were selected under consultation with the inhabitants.

The total area of the two evacuation places exceeds 1hectars, and can accommodate some 5,000 people easily, much more than the total number of the inhabitants and the expected tourists. On the other hand, the conditions of existing trails to the two places are very bad. To ensure safe and prompt evacuation of even elderly people, evacuation routes should be constructed by providing stairs.

(3) Stock of Material and Equipment

Materials and equipment necessary for evacuation, rescue and relief activities shall be list up and reserved at designated places. Shovels, ropes, torches, blankets, knives, radio sets, medicines, foods, etc. are recommended to be stocked in every household and/or public places.

(4) Guidance of Evacuees

The evacuation cell is responsible for smooth execution of evacuation, and they must guide inhabitants to designated evacuation places. Infants, elderly and physically handicapped people should be evacuated first. The rescue and relief is responsible for rescue and relief activities of injured people.

(5) Guidance of Tourists

A tourists-guiding cell shall be formed among employers and employees of hotels, restaurants, shops, etc. The cell must guide tourists who are not familiar with disasters in the places to designated evacuation places promptly and safely.

(6) Control of Traffic

Control of traffic during a flood time is one of the big problems in the Ourika Valley. In summer weekends some 300 cars are parked on the road P2017, making two 1km long lines on the both sides of the road.

As seen in the 1995 flood and the 12 August 2001 flood, however, this might causes traffic congestions, resulting in a panic, and disturbance and even delay of evacuation activities in the worst case. Lessons from the past floods imply that it is wise to refrain from using cars during a flood, while it seems natural that drivers and passengers rush to their cars after a flood warning message is broadcast. They want to save their precious property, the cars as well as their lives.

Something should be done to control the traffic during a flood, but it seems very difficult for the inhabitants to control the traffic because they have no power to do so. At least 10 or more policemen might be necessary to control as many as some 300 cars, but Royal Mounted Police can not afford to station so many police men at Iraghf. Construction of parking lots at high safe places might be another solution, but a total area of 1ha is necessary to accommodate so many cars. Introduction of an idea so-called “Park and Ride” in which private cars are controlled at the entrance of the valley and the car passengers are transported to the inside of the valley by shuttle bus, should be also discussed as one of the solutions as long as such parking lots are not ensured.

(7) Evacuation Drill

An evacuation drill must be conducted once a year at least as well as a joint communication drill with the Province, DRHT and DPE, etc.

(8) Public Relations

Efforts to publicize the FFWS among inhabitants and tourists shall be made continuously. Signboards explaining the FFWS and past disasters are very effective for this purpose. An evacuation drill is also a good opportunity for inhabitants to understand the system and to be reminded of past dreadful disasters.

(9) Evaluation of Evacuation Activities and Updating of Evacuation Plan

After every flood that reached the Flood Watch Phase or further and every drill, all members of the evacuation organization should meet to evaluate the actual activities and drill for updating the Evacuation Plan.

7.3 Technical Transfer Programs

A variety of technical transfer programs have been carried out during and after the installation work, so that personnel concerned could operate the installed system by themselves as soon as possible. These programs are summarized as follows:

Technical Transfer Programs

Program	Date	Trainees/Participant s	Contents
Installation OJT	23/10/2001 to 2/12/2001	4 DRHT technicians and 5 guardians	4 technicians from DRHT participated in the installation work on the job training basis.
Maintenance training	23/11/2001	5 DRHT technicians	Guidance on preventive maintenance and operation of equipment for the flood watch station was made at Tazzitount Station.
Data processing system operation training	3/12/2001	4 DRHT technicians	Guidance on operation of software for data processing and monitoring was made at the Master Information Center.
Station Guardian Training	7/12/2001	5 station guardians	Guidance on data reading from the RTU (Remote Terminal Unit) was made at Tazzitount Station.
Site visits	11 and 13/12/2001	Some 40 persons from organizations concerned	Participants visited DRHT Master Information Center, Ourika Caidat Monitoring Station, Iragfh Warning Post and Tazzitount Station.
Workshop seminar	12/12/2001	Some 30 persons from organizations concerned	A one-day seminar with 4 lectures was held at a seminar hall of Ministry of Equipment in Marrakech.
Data key-in training	19/12/2001	2 DRHT technicians	Guidance on keying-in of rainfall and water level data was made at the DRHT Master Information Center.
Communication simulation drill	21 and 26/12/2001	DRHT, DPE, Al Haouz Province and DGH	Simulation drills on communication between DRHT and three monitoring stations was held.

Among the above programs, the site visits, workshop seminar and communication simulation drills are described below in detail.

7.3.1 Inauguration Events (Site Visits and Workshop Seminar)

As inauguration events of the Pilot Project Phase I, site visits and a workshop seminar were held between 11 and 13 December 2001. These events aimed to firstly call for interests in and understandings of the Pilot Project among personnel concerned who are to operate and maintain the installed system. The press and a TV crew also participated in the events and reported the Pilot Project in some newspapers and TV programs.

(1) Site Visit Tour

Two site visit tours were organized for officials and representatives of organizations concerned. The first tour held on 11 December was for higher-ranking officials, namely directors or their substitutes, and representatives of local authorities. The second one on 13 December was for the other officials, but its contents were the same as the first one.

In these tours, the Master Information Center (MIC) at DRHT, the Ourika Caidat Monitoring Station, the Iraghf Warning Post and the Tazziount Station were visited. In MIC, the data processing system consisting of a PC server and a client PC was demonstrated, following explanation of the general procedure of the pilot FFWS. At Ourika Caidat the PC for monitoring and the VHF radiotelephone for communication with the warning post were demonstrated to participants, although the PC could not be connected to the MIC server unfortunately due to a trouble of the telephone line. Broadcasting of fictitious warning messages was tried through the loud-speakers at the Iraghf warning Post. The hydrological observation equipment including an ultrasonic water level gauge were demonstrated at Tazzitount Station.

(2) Workshop Seminar

A workshop seminar was held on 12 December at a seminar hall of L'INSTITUT DES TECHNICIENS SPECIALISES DES TRAVAUX PUBLICS in Marrakech. Following the opening speeches by the Director of DRHT and the Resident Representative of the JICA Morocco Office, four lectures and discussions were made as follows:

Lecturers in Workshop Seminar

Lecture	Organization	Title of Lecture
Mr. Hassan ARESMOUK	DRHT	Flood Problems in Ourika River Basin
Mr. Takeshi SASAHARA	JICA Study Team	Installation of FFWS Equipment in Ourika River Basin
Mr. Masami KATAYAMA	JICA Study Team	Guidelines for Operation of Pilot Project
Mr. Yoshiharu MATSUMOTO	JICA Study Team	Trafic Control in Flood Disaster Area in Japan

7.3.2 Communication Simulation Drill

A communication simulation drill between DRHT and three monitoring stations, DPE, Al Haouz Province and DGH were tried two times on 21 and 26 December 2001, in order to have personnel concerned get used to the new equipment and the operation procedures in accordance with the proposed guidelines and to extract problems involved in the procedures.

(1) General Procedure

The procedure of the drills was as follows:

- DRHT sends a Pre River Flood Notice by fax to the three monitoring stations, Al Haouz Province, DPE Al Haouz and DGH respectively,
- Each monitoring station returns a telephone call to DRHT for confirmation of receiving of the notice message,
- Each monitoring station turns on its PC and connects it to the DRHT server by dialing,
- Each monitoring station telephones DRHT once the coneection is made,
- DRHT send a cancellation message of the flood notice to the monitoring stations by fax,
- And each monitoring station telephones DRHT for confirmation of receiving the cancellation message.

(2) Simulation Results

Time that the organizations consumed in every procedure is presented as follows:

Time Consumed in Communication Procedures

Procedure	Consumed Time on 21 Dec. (min.)			Consumed Time on 26 Dec. (min.)		
	Province	DPE	DGH	Province	DPE	DGH

Receiving of first flood notice by Fax	12	8	9	5	7	9
Switching on PC and connection to the server of DRHT	45 (57)	30 (38)	30 (39)	20 (25)	22 (27)	10 (19)
Receiving of second flood notice by Fax	13 (70)	5 (43)	3 (42)	15 (40)	5 (32)	5 (24)
Disconnection with the server and switching off PC	15 (85)	10 (53)	15 (57)	5 (45)	10 (42)	15 (39)
Total necessary time	85	53	57	45	42	39

( ) : cumulative time

(3) Problems of System Operation Specified from Simulation Results

Judging from the simulation results mentioned above, major problems of operation of the system were specified as follows:

- It takes a long time to send the first flood information from DRHT to each agency by Fax. This is attributed to that only one telephone line is available in DRHT for sending Fax. Consequently, DRHT send the Fax one by one to each agency resulting taking a long time. Furthermore, receiving side (each agency) has also one telephone line available, so that sometimes communication condition is not good; namely, the line is occupied.
- After receiving the Fax of flood information, it took more than 30 minutes to access the server of DRHT. This is also due to the situation that each agency has only one telephone line available, which is used for Fax, telephone and PC dial up communication.
- On the other hand, DRHT has only two exclusive telephone lines for dial up communication, so that only two agencies can access to DRHT server at same time and the other agencies cannot access during that time.
- Besides, the person in charge in each agency for dial up communication is not familiar with the system yet. Therefore, DRHT dispatched an engineer to assist the system operation in each agency. However, such situation is also attributed to taking a long time for the simulation.

Among above problems, the most serious problems were:

- Shortage of telephone lines for system operation
- Unfamiliarity of personnel concerned with the new system

Based on the results of the simulation drills, the Study Team strongly requested DRHT and the monitoring stations to regularly conduct such a simulation drill and to install new exclusive telephone lines.

7.3.3 Evacuation Drill

An evacuation simulation drill was carried out at Iraghf on 12 February 2002 with participation of some 40 local volunteers.

(1) Objective of Implementation of the Evacuation Drill

Flood warnings are to be broadcasted at the Iragfh area, whenever a flood risk is detected. With the warning messages, inhabitants as well as tourists are advised to get prepared and/or immediately evacuate themselves to safer places. It is important for them to get familiar with evacuation procedures including evacuation routes and evacuation sites.

The objectives of the evacuation drill are to have inhabitants get familiar with the evacuation procedures through the drill and to extract problems involved in the procedures. Such a drill is expected to result in minimization of flood victims.

(2) Basic Procedure of the Drill

Generally an evacuation drill is undertaken in the following procedures:

- Broadcasting of Flood Caution Message
- Gathering of participants at predefined meeting points by group. (Participants are divided into several groups in advance.)
- Broadcasting of Evacuation Adivice Message
- Evacuation of perticipantsto predefined places under the guidnce of each group leader
- Waiting and watching of perticipants at the evacuation places
- Broadcasting of Cancellation Message
- Return of participants/inhabitants to the meeting point
- Discussions by all the perticipants on the evacuation drill by all the perticipants
- Dissolution

(2) Implementation of Evacuation Drill

The evacuation drill was implemented on February 12 in the following procedures:

Procedure of Evacuation Drill

Time	Announcement	Evacuation Activities by Participants
10:00	Announcement of Implementation of Evacuation Drill	-
11:00	Broadcasting of Flood Caution Message	Gathering at meeting points
11:10	Broadcasting of Evacuation Advice	Move to evacuation places and watch and wait there
11:30	Broadcasting of Cancellation Message	Return to meeting points
11:40	Evaluation and Discussion on Evacuation Drill	-
12:30	Dissolution	-

(3) Results of Evacuation Drill

A total of 44 inhabitants participated in the evacuation drill. They were divided into three groups. The consumed time for the evacuation activities of each group is given in the following table:

Result of Evacuation Drill

Time	Announcement	Evacuation Activities	Consumed Time (min.)		
			Group 1	Group 2	Group 3
11:00	Flood Caution Message	Gathering at meeting points	5 (20)	7 (11)	1 (13)
11:10	Evacuation Alert Message	Move to evacuation site and watch and wait at the site	4 (20)	3 (9)	2 (15)
11:40	Cancellation of alert	Return to meeting points	6 (20)	4 (9)	3 (15)

( ) : Number of participants

Judging from the table, the followings are specified:

- The number of persons more than expected partcipated in the evacuation drill.
- The consumed time for evacuation activities was relatively short, though it may be still some points to be improved to shorten the time.
- Movement to evacuation site was very swift and smoothly performed. However, in the Group 2, two eleder persons gave up moving to the evacuation place, because of dificulty to access the site.
- As a general conclusion, the evacuation drill could be undertaken successfully.

In the discussions after the evacuation drill, the followings were pointed out:

- The evacuation drill was conducted in day time, but to assure the smooth activities even in night time, it is necessary to provide street light along the road.
- Since it was in winter, off-season, there was a very limited traffic on the road. In summer, however, several hundreds of vehicles enter the Ourika Valley. It is necessary to control the traffic to assure the smooth activities of evacuees and also to avoid the traffic accidents.
- The warning messages broadcast from the warning post are understandable and acceptable.
- The inhabitants expressed their understandings on neccecity of an evacuation organization among them.

7.4 Global Simulation Drill

7.4.1 Introduction

A global FFWS simulation drill was successfully performed on 25 June 2002 with participation of inhabitants and tourists at Iraghf in the Ourika Valley, and organizations concerned including ABHT, DPE, DGH, DMN, Al Haouz Province, Tahanout Cercle, Ourika Caidat, Setti Fadma Rural Commune, Royal Mouted Police, Civil Protection, Public Health, Auxiliary Force, etc., using the Pilot Project Phase I equipment, on the assumption that a certain flood took place in the valley.

As described in the previous section, communication drills between ABHT (DRHT) and the Province, between ABHT and DPE Al Haouz and between ABHT and DGH were made two times in December 2001. An evacuation drill was also executed at Iraghf in February 2002. This global simulation drill, which includes procedures of those previous drills as parts, covered all components of the total FFWS procedures with participation of all the organizations concerned.

Hydrological data were transmitted from the flood watch stations to ABHT through radiotelephones. DMN Alert Message, ABHT Flood Notices and Flood Warnings by Al Haouz Province were disseminated to the organizations concerned through pre-defined routes, and evacuation of not only some 130 inhabitants but also 13 tourists was made at Iraghf according to messages broadcast from the warning post.

Objectives of the global simulation drill were as follows:

- To have inhabitants and personnel of the organizations concerned get more familiar with the equipment and/or the FFWS operation procedures,
- To demonstrate the simulation drill to the Moroccan side as a sample of simulation drills, which they are adviced to conduct by themselves,
- To extract problems involved in the procedures, and
- To inspect the conditions of the equipment installed in the Pilot Project Phase I,

7.4.2 Preparation Activities

Preparation activities for the simulation drill were commenced as soon as the Study resumed in May 2002, as follows:

(1) Preparation of Scenario

A unique scenario for the global simulation that was to be followed by all participants distributed in Marrakech, Tahanaout, and the Ourika Valley was necessary. Various kinds of scenarios including optimistic, ordinary or pessimistic ones were conceived at the beginning. In conclusion, one of the most optimistic scenarios, as explained in Fig. 7.4.1 had to be applied in due considerations as follows:

(a) Date and Time of Global Simulation Drill (Tuesday, 25 June 2002)

Tuesday, 25 June 2002 was determined as the date of the simulation drill, taking into account the inhabitants' convenience and counting necessary days for the preparation activities. About three hours from 15 to 18 o'clock was selected as the duration of the simulation drill because the time is still within the office hours of the organizations concerned.

Some officials suggested that the global simulation drill be conducted on Saturday or Sunday when more and more tourists gather at Iraghf, and that it be conducted after dark as the 1995 flood took place in the evening. However, the Study Team was not so bald enough to dare execute the global simulation drill calling for participation of innocent tourists under such difficult situations. This kind of evacuation drill that includes tourists was the first trial all over the kingdom of Morocco, and any panic and any accident had to be avoided at any cost. Moreover, the Study Team avoided overtime works of personnel of the government organizations to facilitate their participation in the simulation drill.

(b) Announcement of DMN Alert Message

DMN has been making efforts to improve accuracy of weather forecasting. However, forecasting for a localized area, especially for the High Atlas Region still remains to be improved very much. According to an examination on the accuracy of DMN Alert Messages in Subsection 4.3.1, 4 messages out of 12 messages announced for the region in October 1999 were wrong, and a heavy rainfall of about 40 mm was missed by DMN on the other hand.

As the examination revealed, it is possible that a flood takes place suddenly without any announcement of DMN Alert Messages. In the global simulation drill, however, DMN was supposed to announce an Alert Message at 15 o'clock, before the generation of the flood. With this alert message every organization could stand by from the beginning of the simulation drill.

(c) Rainfall and Water Level Scenarios

Such a big flood over the alert level that calls for evacuation was considered as follows:

The rainfall starts at 15:30, and reaches the pre-alert level and the alert level at 15:50 and at 16:20 respectively, and then ends at 16:40. The water level reaches the pre-alert level at 15:50 and the alert level at 16:20. After reaching its peak at 16:30, the water level goes down below the pre-alert level by 16:50.

Based on the above scenarios, rainfall and water level data of the flood watch stations were prepared as shown in Table 7.4.1, which were distributed to every station in advance.

(2) Confirmation of Procedures of FFWS Operation

Actions/procedures in the FFWS operation to be undertaken by the organizations concerned were proposed as "Guidelines for Experimental Operation of Pilot Project" in the Progress Report. These actions/procedures were in principle to be followed in the global simulation drill too, and were confirmed and further improved through a series of meetings and two test simulation drills presented in Table 7.4.2. Figs. 7.4.2 and 7.4.3 illustrate the transmission routes of the DMN messages, the ABHT Flood Notices and the Flood Warnings by the Province that were finalized for the global simulation drill. Followings are summaries of the actions/procedures undertaken by the principal organizations of the FFWS operation and the evacuation procedures taken on 25 June 2002:

(a) ABHT

Immediately after receiving the DMN Alert Message (Fig 7.4.4), a FFWS operation team composed of a hydrological engineer and two technicians (a radio operator and a computer operator) is mobilized at the Master Information Center. Then the radio operator of ABHT contacts the four flood watch stations, Amenzal, Tiourdiou, Tazzitount, Tourcht by radiotelephone and tells them to start frequent observation and reporting of every 10 minutes. Agouns Station was excluded from the simulation drill because its radiotelephone was out of order.

The radio operator of ABHT receives rainfall and water level data from the stations and enters them in the data sheet every 10 minutes. Then the data sheet is given to the computer operator, who keys in the data to the data processing system. The computer operator and the hydrological engineer keep watching processed hydrological information in the computer display.

Once the rainfalls and/or the water levels exceed(s) the Pre-alert or the Alert levels, or all the rainfalls and all the water levels lower below the Pre-alert levels, they prepare a flood notice message (Pre River Flood Notice, Flood Notice, Cancellation) according to the flood situation. Receiving an approval of the director or his substitute (the deputy director in the simulation drill) on the flood notice, the message is taken to the secretary of the director, who faxes it to Al Haouz Province, DPE, DGH, and DMN. Immediately these organizations are telephoned for confirmation of receipt of the fax messages.

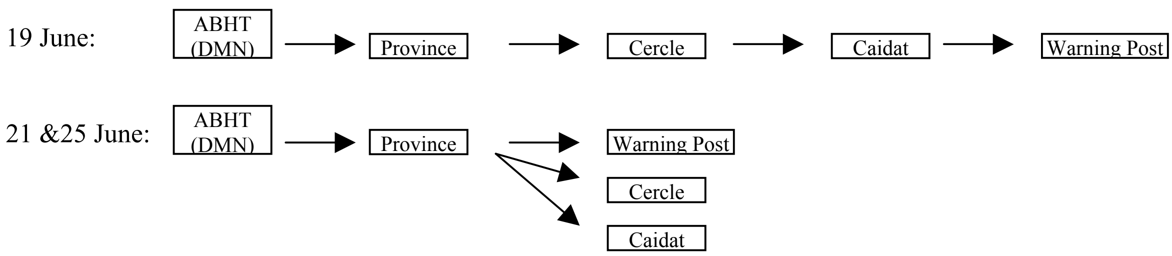
In the first test simulation, they took 10 to 20 minutes to prepare the flood notice messages by using the client personal computer. From the second test simulation, handwriting to enter hydrological data to pre-printed message forms was applied to speed up the procedure. . An example of the flood notice messages made in the simulation drill are presented in Fig 7.4.5.

(b) Al Haouz Province

The transmission cell plays an important role in the Al Haouz Province. Once the DMN message is received, the message is immediately delivered by hand or intercom to the governor or the secretary general if the governor is absent. The DMN message is further diffused under the instruction of the decision maker to DPE, Royal Mounted Police, Civil Protection, Auxillious Force, Public Health, Tahanaout Cercle, Ourika Caidat and the Iraghf Warning Post. The computer installed in the Pilot Project for the FFWS is also turned on, to monitor the flood information sent by ABHT.

The flood notices by ABHT are also delivered to the governor or the secretary general immediately after receiving. Once he decides to issue a flood warning (Flood Caution, Evacuation Advice or Cancellation), the transmission cell prepares the warning message, and diffuses it to the same organizations as the DMN message. The warning messages made in the simulation drill are given in Fig 7.4.6.

In the first test simulation drill held on 19 June 2002, the DMN message and the flood warning messages were disseminated to the warning post indirectly from the Province through Tahanout Cercle and Ourika Caidat in accordance with the administration hierarchy. However, this step-wise procedure resulted in a significantly long dissemination time and misunderstanding of the messages in the test drill as described in Subsection 7.4.3. From the second test simulation drill on 21 June 2002, direct dissemination to the warning post was applied based on discussions made in the meeting held on the following day of the first test drill.



Route of Message Dissemination

The contents of the flood warnings that are disseminated to the warning post were also simplified to make clear instructions to the post after the first test simulation drill, in which the same long messages as the fax letters that were sent to the related organizations were spoken ward by ward to the warning post by Ourika Caidat through the radiotelephone, resulted in confusion of the warning post operator. The simplified messages are presented in Fig 7.4.7.

(2) Iraghf Warning Post

Two operators who were nominated from Setti Fadma Rural Commune have been stationed in the warning post permanently in turn since May 2002. The operator broadcasts warning messages according to instructions of the Province. He speaks directly to the microphone to broadcast the DMN message in an easy-understanding manner. As for the flood warnings, he broadcasts pre-recorded flood warning messages. Immediately after every broadcasting, he reports to the Province. Communication through the radiotelephone with Ourika Caidat who is a delegation of the Province for the Ourika Valley is also made to exchange flood information.

In the global simulation drill, the messages were actually broadcast for the evacuation activities, but not in the test simulation drills on 19 and 21 June 2002, when receipt of the messages was only made at the warning post.

Broadcasting Message

Message	Broadcasting Message	Remarks
Alert Message by DMN	According to the weather forecasting by DMN, it may have local heavy rainfall in the region. Please take care of it.	
Flood Caution by Province	This is the Iraghf Warning Post. Please be informed of a River Flood Caution issued by the Al Haouz Province. Heavy rainfall and/or water level rising are being observed in the upstream of the Ourika River. You are advised to get prepared against further development of the flood and to pay attention to the next broadcast from this warning post.	Recorded Message (Siren + Voice Message)
Evacuation Advice by Province	This is the Iraghf Warning Post. Please be informed of an Evacuation Advice issued by the Al Haouz Province. The flood is further developing into a dangerous level in the upstream. You are advised to evacuate yourself to safer places and to pay attention to the next broadcast from this warning post.	Recorded Message (Siren + Voice Message)
Cancellation Message by Province	This is the Iraghf Warning Post. Please be informed that the Al Haouz Province has cancelled the flood warning(s). The flood risk has passed and the river has settled to normal conditions. Thank you very much for your attention.	Recorded Message (Siren + Voice Message)

(d) Evacuation Activities at Iraghf

The evacuation procedure is the same as that in the evacuation drill made in February 2002, as follows:

- The participants were divided into three (3) groups in advance depending on their locations,
- The participants gather at three predefined meeting points by group after listening to the broadcast of Flood caution Message,
- The participants evacuate themselves to two predefined evacuation places through 3 predefined evacuation routes under the guidnce of each group leader after listening to the broadcast of Evacuation Advice Message,
- The participants keep waiting at the evacuation places,
- The participants return to the meeting points after listening to the broadcast of Cancellation Message, and then dissolve there.

(e) Other Organizations

In addition to the above, DMN Marrakech, DGH, DPE Al Haouz, Oukaimedan Brigade of DPE, Tahanaout Cercle, Ourika Caidat, Setti Fadma Rural Commune, Royal Mounted Police Tahanaout, Ourika Brigade of Royal Mounted Police, Civil Protection Marrakech, Ait Ourir Post of Civil Protection, Auxiliary Force Tahanaout, Public Health Tahanaout and Setti Fadma Health Center participated in the global simulation drill mainly for the message transmission as illustrated in Figs. 7.4.2 and 7.4.3.

(3) Preparation of Leaflet, Map and Signboards

In order to facilitate the evacuation drill at Iraghf, a leaflet calling for participation of tourists in the drill, a tourist guide map showing the evacuation routes and places as well as café restaurants, and signboards directing the meeting points and the evacuation routes were prepared. The leaflet is presented in Fig. 7.4.8, and a reduction copy of the map and the signboards are given in Fig. 7.4.9.

Some 100 copies of the leaflets were produced and then distributed to inhabitants and tourists at Iraghf on 25 June 2002. A copy of the tourist map was hung on the gate of the warning post, and three copies on trees of restaurant gardens. For each of the meeting points and the evacuation routes, an arrow signboard was placed.

7.4.3 Results and Evaluation of Global Simulation Drill

Prior to the global simulation drill, two test simulation drills that did not include the evacuation activities were also carried out on 19 and 21 June 2002. The first test drill was planned and organized by the Study Team, and the second test drill was additionally conducted with strong initiatives of the governor of Al Haouz Province who was dissatisfied with results of the first test drill. Through the two test simulation drills the organizations concerned got more familiar with the equipment and the procedures. The evaluation meetings that were held after the test drills were good opportunities for improvement of the procedures. Then the global simulation drill was executed on Tuesday, 25 June 2002, involving voluntary inhabitants and tourists at Iraghf too.

(1) Message Issuance and Dissemination on Lifelines of FFWS

The transmission routes from DMN or ABHT to the Iraghf Warning Post via the Province are so-called lifelines of this FFWS. The success of the FFWS depends very much on how fast the messages are transmitted on these lines. For example, in the draft Master Plan proposed in the Interim Report 2, a total of 30 minutes is allowed for all the procedures including evacuation activities. If 10 minutes that is considered as allowable time for evacuation activities in the Master Plan is excluded, only 20 minutes is allowed for ABHT, the Province and the warning post to collect hydrological data, announce a Flood Notice, issue an Evacuation Advice, and disseminate it to the warning post.

Table 7.4.3 gives detailed records of consumed time in each procedure of the simulation drills, and Figs. 7.4.10, 7.4.11 and 7.4.12 illustrate on a timetable the procedures and the message flows made in the three simulation drills. The total consumed time until the receipt of the messages by the warning post is summarized as follows:

Summary of Consumed Time Until Receipt of Messages by Warning Post

Simulation Drill	Date	DMN Alert	Pre Flood Notice/ Flood Caution	Flood Notice/ Evacuation Advice	Cancellation
1st Test Simulation Drill	19 June	70	76	65*	45*
2nd Test Simulation Drill	21 June	7	15	18	13
Global Simulation Drill	25 June	13	18	15	15

* : Consumed time until the receipt of the message by Ourika Caidat (Since the radiotelephone of the warning became out of order, the Evacuation Advice and Cancellation messages could not be transmitted to the warning post.

(a) Consumed Time

Each procedure was speeded up greatly through the test simulation drills. The total consumed time from the hydrological data collection by ABHT to the receipt of the warning messages by the warning post was shortened by as much as 30 to 60 minutes from the first test simulation. In the global simulation drill, the DMN alert message was disseminated to the Warning Post in 23 minutes. As for a sequence of procedures for the Flood Warnings, it took 15 to 18 minutes from the data collection by ABHT to the message dissemination to the Warning Post by the Province.

This total consumed time of 15 to 18 minutes seems satisfactory, compared with 20 minutes, the target time of the Master Plan. However, it should be noted that the short operation time was attained under the conditions that the all administrations were previously informed and were ready at the commencement of the drill. It is natural to think that it takes longer time in an actual flood.

(b) Quality of Messages

Quality of the messages that were disseminated to the final destination, the warning post was also greatly improved. In the first test simulation drill the same long messages as the fax letters that was sent to the related organizations were spoken ward by ward to the warning post by Ourika Caidat through the radiotelephone, resulted in confusion of the warning post operator. After the test drill, simplification of the messages was done as shown in Fig 7.4.7. All the messages were so simple and clear that the warning post operator could easily understand them.

(c) Bypassing of Cercle and Caidat

After the first test simulation the messages were disseminated from the Province directly to the warning post, bypassing Tahanaout Cercle and Ourika Caidat, ignoring the administration hierarchy, in order to inform the messages to the post as soon as possible. This bypassing was very successful in terms of the speeding-up of the procedures.

On the other hand, it should be stressed that Ourika Caidat is still a supervisory administration of the warning post. During the FFWS operation Ourika Caidat must keep close contact each other with the Warning Post and Tahanout Cercle to collect necessary information for appropriate interventions.

(d) Handwriting of Flood Notices

Introduction of handwriting for preparation of the flood notice messages also contributed to speed–up.

(e) Necessary Staff for Operation

Through the simulation drills it is identified that each of ABHT and the Province needs a FFWS operation team composed of one chief and two assistants (technicians) at least.

(2) Evacuation

The weather was fine and not so hot at Iraghf on 25 June 2002. Dozens of Moroccan tourists were seen in the gardens of the café restaurants. In the afternoon from about 16 o'clock to about 17 o'clock, evacuation activities of a total of 142 voluntary participants including 13 tourists were made there as a part of the global simulation drill. The governor of Al Haouz Province was also present to inspect the evacuation activities.

The participants were divided into three (3) groups depending on their locations, each of which was directed in advance to the nearest meeting point and the nearest evacuation route. The number of the participants and the consumed time for each group are tabulated as follows:

Summary Result of Evacuation Activities

Activities	Item		Group 1	Group 2	Group 3	Total
Gathering at Meeting Point after Broadcasting of Flood Caution	Number of Participants	Inhabitants	34	50	45	129
		Tourists	1	5	7	13
		Total	35	55	52	142
	Consumed Time (minutes)		1	5	1	N/a
Evacuating from Meeting Point to Evacuation Place after Broadcasting of Evacuation Advice	Number of Participants	Inhabitants	20	50	34	104
		Tourists	3	5	4	12
		Total	23	55	38	116
	Consumed Time (minutes)		2	3	2	N/a
Returning to Meeting Point and Resolution Broadcasting of Cancellation	Number of Participants	Inhabitants	20	40	34	94
		Tourists	3	5	4	12
		Total	23	45	38	106
	Consumed Time (minutes)		6	4	3	N/a

Generally speaking, the evacuation activities were carried out successfully and smoothly without any panics and accidents. The followings are observations made for the evacuation activities:

(a) Participants

Some 130 inhabitants that accounts for as much as 32 % of the population of the Iraghf village (1994 Census) participated seriously in the evacuation activities. It can be said that this high participation rate reflects keen interest and enthusiasm of the inhabitants in the evacuation activities and that they recognize necessity of such evacuation drills. On the other hand the tourist participants are very few, only 13, as expected before, because that day was Tuesday a little before the full tourist season.

Besides, almost all the participants were men, and only a few tourist women were seen among the participants. It seems difficult to win local women's participation in such a social activity in the rural area.

(b) Consumed Time

All the groups could take prompt actions and move swiftly to the evacuation places. They could evacuate themselves from the meeting points to the evacuation places in only two to three minutes. The total time for all the procedures from data collection to completion of the evacuation is also about 20 minutes, less than 30 minutes of the target time for the draft Master plan.

(c) Mistake in Recognizing Warning Messages

Some impetuous participants took wrong actions without listening to the warning messages that followed the sirens. They made mistakes in recognizing the messages.

(d) Traffic

The traffic was so light that the evacuees could move smoothly without any obstacles on the road.

(e) Evacuation Route and Place

Some problems were found in the upper evacuation place presented in Fig. 7.4.9, which was designated for the group 3 in the evacuation activities. A few participants could not climb the steep evacuation route and gave up the evacuation. On the evacuation place there are many big rocks fallen from the mountain slope, and more rocks are seen ready to fall even with a small stimulus.

7.4.4 Evaluations and Recommendations

(1) Evaluations

The global simulation drill was very successfully undertaken on 25 June 2002, of course, greatly thanks to the optimistic scenario explained in Subsection 7.4.2. As a conclusion, the simulation results are evaluated as follows:

- The effectiveness of the two test simulation drills was remarkable. The consumed time decreased by 30 to 60 minutes. The quality of the messages was also very much improved. It is not only becasuse the operation procedures were modified after the first test simulation, but also because all the participants of the organizations concerned got more familiar with the equipment and the procedures through the test simulation drills.
- In the global simulation drill the total time consumed in the lifelines of the FFWS from the hydrological data collection by ABHT to the execution of evacuation was about 20 minutes, which is still considered within a affordable limit, compared with the target time of 30 minutes in the draft Master Plan.
- The contents of the messages were also correctly disseminated to the warning post, where the operator could broadcast the warning messages over the Iraghf area properly and immediatley, although confusion of the post operator was observed the first test simulation. The broadcast messages led the evacuees smoothly.
- Generally the equipment functioned properly during the simulation drills, although the radiotelephone of the Iraghf Warning Post became out of order in the first test drill. It can be said that the eauipment have been somehow mainteined until June 2002.
- All the participants including those from the organizations concerned and those from the Iraghf village were very enthusiastic and serious in the drills. This is one of the reasons why the simulation drills were executed smoothly without any panics nor accidents.

(2) Recommendations

To further improve the FFWS operation, several recommendations are made as follows:

(a) Periodical Execution of Simulation Drill

As mentioned in Section 7.4.1, one of the objectives of the above simulation drills that were mainly initiated and organized by the Study Team was to demonstrate to the Moroccan side a sample of simulation drills. From now on the Moroccan side is requested to conduct such a simulation drill by themselves.

A global simulation drill involving all the organizations concerned should be made in June or July, in the beginning of the tourist season. Individual or small-scale simulation drills involving a single organization or a few organizations should be carried out more frequently to train the organization personnel. More pessimistic scenarios are also recommended in order to examine if the FFWS operates properly in a harder situation, for example nighttime, and weekend. Another problems of the FFWS, which could be clues for further improvement, can be found in the simulation drill of the different scenario.

(b) Operation and Maintenance of System Equipment

To ensure the sustainable operation of the equipment, a sustainable maintenance system should be established among ABHT, DGH, DPE and Al Haouz Province.

(c) Improvement of Evacuation Procedures, Routes and Places

The evacuation activities in the global simulation drill were carried out successfully and smoothly as planned. However, It is true that there still remain many things to be solved in the evacuation procedure, such as how to encourage village women to participate in evacuation drills, how to guide to the evacuation places as many tourists as expected in mid-summer, how to control traffic during flood times, etc. It is necessary to continue to improve the evacuation procedure through the above-mentioned periodical execution of drills.

In addition, some problems in safety were found in the upper evacuation place and its access route. In addition, necessity of public lights is repeatedly pointed out by the Iraghf inhabitants who experienced difficulties in evacuating themselves in the dark of the 1995 flood. Improvement of evacuation places and routes is indispensable to facilitate evacuation activities.

(d) Strengthening of Activities by Local Association

To guide tourists to the evacuation places, contribution of the local inhabitants that know very well the places and the flood characteristics is indispensable. On the other hand, the inhabitants, most of which are employers or employees of café restaurants, become beneficiaries if the reputation of this area is raised among Moroccan and foreign tourists through such disaster prevention activities of the inhabitants. In other wards, they have an incentive enough to positively participate in the activities. Fortunately, there is an association composed of hotel and café owners in the Ourika Valley. In the Iragfh area alone, there are about 50 members of the association, who could possibly play a important role for the disaster prevention activities.

It is strongly recommended that the association, of which activities are actually dormant at present, should be strengthened and reorganized to systematically undertake the evacuation activities including guidance of tourists and traffic control, as already stressed repeatedly. It is further suggested that the operation of the warning post be entrusted to the association in future. This kind of people’s participation could contribute to reduce burdens of the governmental organizations, too,

(e) Utilization of Warning Post

The warning post plays an important role in broadcasting the flood messages in flood times, while it is not be used for the other purposes. Since this is an effective tool for public relations, it should be examined to utilize the warning post facilities more frequently and effectively, including the following activities, so that the inhabitants and tourists will pay more attention to the broadcasts from the warning post:

- Weather forecasting by DMN
- Major events held in the Ourika Valley or in the neighboring areas
- Introduction of activities for flood mitigation taken by the local association
- Introduction of tourists spot and major industries including products
- Advertisement of hotel, café, souvenir shop, etc.,
- General guidance as a travel information center
- Others

(f) Publicizing of Risks in the Valley

It is very important to let tourists know about the risks of flood disasters in the Ourika Valley. This awareness helps tourists understand the flood situation and take a immediate and proper action when a flood takes place.

According to a tourist survey conducted by the Study Team in August 2000, as much as 92 % of the tourist interviewees answered that they knew about the 1995 disaster. As time goes by, however, the memory will be lost gradually. Therefore, efforts to keep people reminded of the risk of flood disasters should be continued. For example, it is proposed to hoist large signboards calling for attention to the risks of disasters due to debris flows and floods in the Ourika Valley.

(g) Strengthening of Permanence System

As mentioned in Subsection 7.4.3, the two principal organizations of the lifelines of the FFWS operation, namely ABHT and Al Haouz Province need an operation team composed of three persons at least respectively. It might be not difficult to immediately mobilize such a team in the office hours. Under the present permanent systems of the two organizations, however, it seems difficult to do so at night, when a flood is likely to take place. During the tourist season in July and August at least, strengthening of their permanence systems is necessary.

(h) Review and Updating of Hydrological Indicators for Flood Notices and Flood Forecasting Program

The present FFWS procedures are greatly dependant upon hydrological information of ABHT. The other related administrations take concrete anti-disaster actions according to the flood notices, which are interpretations of hydrological information by ABHT. In this sense, the responsibility of ABHT as a technical organization is very heavy, and it must continue to make efforts to provide more precise information.

In this Pilot Project, pre-alert and alert levels of rainfall, water level and discharge have been proposed as hydrological indicators for the announcement of flood notices. In addition, a flood forecasting computer program was developed to assist ABHT to follow up flood situations. However, these indicators and the program were tentative ones that were determined, reluctantly based on scarce hydrological data. It is strongly recommended that ABHT reviews the hydrological indicators and the flood forecasting program after every certain flood through the examination of hydrological data to be obtained by the new system and the close observation of the flood phenomena at the sites. If necessary, they should be revised.

(i) Establishment of Coordination Committee

To fulfill the above recommendations, a strong coordination body is necessary. In this sense, a coordination committee should be created among all the government organizations that were involved in the global simulation drill and the local association. Probably the governor of Al Haouz Province who is essentially responsible for coordination in the province is a suitable person as the chairman of the committee. The governor executed his leadership in the global simulation drill too.

7.5 Maintenance of Equipment

According to the contract between JICA and the Japanese supplier, Japan Radio Co., Ltd. (JRC), all the equipment are guaranteed by the supplier for one year from 15 August 2001. Within this guarantee period, any equipment that become out of order are to be repaired or replaced free of charge by the Japanese company. However, the Moroccan government must shoulder all repair costs immediately after then. In order to secure sustainable operation of the Pilot Project of which equipment have been distributed to several different organizations and locations, a maintenance system should be newly established. In the maintenance system responsibilities of each organization and financial sources should be clear.

In late November 2001 representatives of the two main organizations for the Pilot Project, namely the director of DRHT(ABHT) and the governor of Al Haouz Province had a discussion on operation and maintenance of the project at the presence of the Study Team, and agreed in principle as follows:

- Each organization is responsible for operation and daily maintenance of equipment and facilities that have been built and installed in its own jurisdictions.

- DGH, which is the main counterpart organization for the Study, is responsible for preventive and correction maintenance of all the equipment of the Pilot Project. Costs for the correction maintenance is covered by a budjet to be drawn up specially for the project..

In accordance with the agreement, every organization concerned started the operation of the Pilot Project equipment gradually after the completion of the installation works. In January 2003 ABHT, subsidized by DGH, made a one-year maintenance contract for the phase-I equipment with a local agent. This Dhs 120,000 contract covers the cost for both preventive and correction maintenance, although that of spare parts are additionally charged.

7.6 Actual Operation During 14 June 2003 Flood

7.6.1 Introduction

In the afternoon of Saturday, 14 June 2003, a small flood took place in the Ourika River Basin. Fortunately dead nor injured casualties have been reported although flood water mixed with debris from the Tarzaza Tributary choked the bridge of the Road P2017 and undermined a mosque beside the bridge. The traffic was cut at the bridge about 5 hours.

Tarzaza Tributary: The mosque was undermined by the flood water. (taken on 19 July 2003)

The flood was the first flood after the completion of the Pilot Project Phase-II in December 2001. It was not so significant in terms of damages but very important for those involved in the disaster management. Firstly it could be a precious sample to check if the pilot system worked effectively during the actual flood. It is possible to find problems of the Pilot Project Phase-I through a close examination of what happened during the flood. Secondly the flood reminded us of the danger of flood and debris flow from tributaries again, similar to the 12 August 2001 flood descried in Section 4.6.

This section describes results of interview surveys made to personnel concerned to make clear how the related organizations responded to the flood. Then discussions are made on the reactions of the organizations in relation to the pilot system. Moreover, the risk of floods and debris flows from tributaries is also discussed.

7.6.2 Hydrological Conditions

(1) Rainfall

It was fine in the morning, and clouds began to develop in the afternoon. Then it began to rain around 1400 hours in the northwest part of the Ourika River Basin. The rainfall became stronger after 1500 hours and lasted until about 1730 hours.

The spatial daily rainfall distribution is presented in Fig. 7.6.2. The Agouns Station recorded the heaviest rainfall of 35 mm, followed by the Aghbalau Station of **19** mm. The Tazzitount, Tourcht, Tiourdiou and Amenzal Stations had rainfall of 9, 7, 3 and 0.5 mm respectively. As seen in the figure, the high-intensity rainfall concentrated in the northwest part of the Ourika River Basin, namely in the catchment area of the Tarzaza Tributary, resulting in a flash flood that destroyed the mosque.

(2) River Discharge

The two discharge hydrographs in Fig, 7.6.1 are very interesting. The peak discharge at Tazzitount was only 15 m^3/s, but that of Aghbalau was as large as 197 m^3/s. Most of the big discharge gap is probably contribution of the Tarzaza Tributary.

It is interesting that the peak river discharge appeared at the lower station of Aghbalau an hour earlier than at the upper station of Tazzitout. This fact shows that floods of tributaries are much faster than that of the main river stream. Short and steep channels of the tributaries are the main reason of the fast floods. If debris is mixed, the floods are becoming more and more destructive.

7.6.3 Activities of Organizations Concerned

Through a series of interviews between June and July 2003, activities of the related organizations during the flood could be made clear to some extent. It is generally concluded that the conventional system of the province worked very well but the other important part, that of ABHT could not play a role as a flood information provider due to its organizational problems.

It was the Agbhalau Station who telephoned to the mobile phone of the Ourika Caidat around 1530 hours to inform the occurrence of heavy rainfall at Agouns. The station guardian who was informed of the generation of the flood from the Agouns and Tiourdiou Stations called ABHT as usual by radio telephone, but no answer was returned because the radio operator of the day was not there. Thus the guardian had to contact the Ourika Caidat alternatively.

The conventional network of the province functioned well after the Ourika Caidat was informed by the Aghbalau Station. The Ourika Caidat who got a permission of the Governor to broadcast a flood warning at the Iraghf Warning Post, directed his Khalifa to let the warning post announce a warning message who was fortunately at Iraghf at that time. And then a warning message was announced from the laud-speakers over the tourist area.

(1) DMN Alert Message

It was at 1645 hours, after the most of the rainfall dropped already that DMN announced an alert message of thunderstorms and showers with strong winds over the areas including the Marrakech region.

(2) ABHT

ABHT was very unfortunate on that day. It was Saturday. The office was in principle off except a guardian and a technician on permanence duty. Two technicians of the Service of Following-up and Evaluation of Water Resources that is responsible for the FFWS operation were in mountainous sites of the installation work with the JICA installation teams. A remaining technician who was on duty as the radio operator had to go to the Tazzitount Station to repair the radiotelephone.

The technician on duty left ABHT for the Tazzitount Station after receiving reports on hydrological data and the weather from the flood watch stations at 0900 hours. It was only just before 1700 hours that he came back to ABHT from Tazzitount. According to the ABHT permanence rule, 1500 hours' communication with the flood watch stations on Saturday can be skipped if there is no symptom of rainfall seen at the 0900 hours' observation. He did not have to stay in ABHT according to the rule. However, unfortunately the flood took place while he was not in ABHT but in Tazzitount. There was a guardian in ABHT at that time, but he is not authorized to access to the radio room. There was no one in the radio room of ABHT around 1530 hours when the Agbhalau Station called ABHT. It was after 1700 hours that ABHT was informed of the flood by the stations and contacted at last the province, who had known the flood already.

(3) Ourika Caidat

The Ourika Caidat was informed around 1530 hours of the generation of the flood by the Agbhalau Station. He immediately telephoned not only the governor, Royal Mounted Police and Civil Protection but also his Khalifa, chaikh, macadams in the Ourika Valley in order to inform them of the flood and/or to collect information on the flood situations. Moreover, he departed by car to enter the valley to lead interventions at sites with the chief of the Ourika Brigade of Royal Mounted Police, although he was blocked by the flood water from the Tarzarza Tributary.

On the way to the valley, he got from the governor a permission to broadcast a warning message at Iraghf to evacuate tourists from the river through his mobile phone, and then directed his Khalifa to let the warning post announce a warning message by using the microphone but the recorded messages in a gentle manner not to panic people.

(4) Iraghf Warning Post

There were hundreds of tourists at the Iraghf area. It began to rain around 1530 hours with thunder, lightening and hail. The heavy rainfall continued about an hour until 1630 hours.

The operator of the Iraghf Warning Post received a phone call from the Khalifa of the Ourika Caidat at his mobile phone around 1530 hours, saying that a small flood that had been generated at Tiourdiou was coming down, and then he was told to broadcast a warning message as the Khalifa was directed by the caidat. According to the operator, the voice message in Arabic was probably as follows:

"Please be careful. A flood is coming. Please do not be afraid. The flood is small. Please just evacuate from the river to safe places."

Listening to the message, the café and restaurant owners began to move tables and chairs out of the rivers, and most of tourists began to leave Iraghf by car, discouraged by the increasing rainfall too.

7.6.4 Threats of Flood and Debris Flow from Tributary

Since the rainfall concentrated on the northwest part of the Ourika River Basin, the river discharge was not so significant in the upper stretches upstream of the Tarzaza Tributary where main tourists spots such as Iraghf and Setti Fadma are located. This is probably one of the reasons why flood damage was slight in spite of the weekend.

Tarzaza Tributary: The bridge of the Road P2017 is choked with debirs. (taken on 16 June 2003)

On the other hand, a flash flood was generated on the biggest tributary of the Ourika River, the Tarzaza Tributary. The Tarzaza Tributary with a catchment area of 105 km^2 is usually dry. Receiving the intensive rainfall, the tributary swollen into nearly $200m^3/s$. This flash flood destroyed the foundation of a mosque and choked completely the bridge of the Route P2017 with debris. The flood water overflowed the choked bridge, resulting in the traffic cut of about 5 hours.

The flood reminded us of the danger of tributaries again, similar to the 12 August 2001 flood descried in Section 4.6. In the 2001 flood the rainfall quantity was not enough to develop the river discharge but its strong intensity generated sediment discharge on the tributaries between Aghbalau and Setti Fadma. The left tributaries spit out debris on the Route P2017, resulting in blocking the traffic. Fortunately the damages of the both floods were minimal, but they could have made catastrophes including loss of human lives if it had rained a little more.

It should be noted that floods of tributaries are more dangerous and more difficult to forecast than those of main rivers. They are easily generated even by spatially limited rainfall. They flow down much faster. In addition, they include possibility of debris flow, more destructive disaster.

7.6.5 Lessons from the Flood

Through the above play-backing of the flood on 14 June 2003, many problems contained in the flood protection measures can be extracted. These are all precious lessons not only for improving the FFWS but also for protecting the Atlas region from rain-induced disasters. Most of them, however, were already discussed in Section 4.6 in relation to the 12 August 2001 flood. Only two issues are highlighted as follows:

(1) Necessity of Strengthening of Permanence Duty System of ABHT

It is a great regret that ABHT could not provide the flood information to the related organizations. In the Pilot Project, ABHT is supposed as an information center. This means that ABHT is a source of flood information for the related organizations including the province, DPE, etc. If the information center can not provide information, the center is meaningless. Precious equipment installed in the Pilot Project are also useless.

To attain the original purpose of ABHT, strengthening of its permanence duty system is indispensable. Whether weekend or not, at least a technician who can operate the radiotelephone and the client PC of the Master information Center should be stationed 24 hours on duty. In addition, he should be allowed to access to a telephone and a fax as a emergency communication measure.

(2) Necessity of Protection Measures against Flood and Debris Flow

As repeated in the above, floods and debris flows from tributaries are more dangerous and more difficult to tackle with than those of the main river. Even if occurrence of floods and/or debris flows can be forecasted, they generally do not allow enough time to evacuate.

Special attentions should be paid to debris flows. Basically provision of check dams and afforestation that are now being implemented in the Ourika River Basin by DREF are effective to stabilize mountain slopes and streams. However, it is still hard to eliminate all possibility of debris flows even by providing these structural and vegetation measures. It is important to monitor the probable debris flow streams defined in Subsection 3.1.2.

CHAPTER 8. IMPLEMENTATION AND EXPERIMENTAL OPERATION OF PILOT PROJECT PHASE-II

8.1 Implementation Work

As described in Chapter 6, the Pilot Project was implemented step-wisely between 2001 and 2003. The second phase work is mainly composed of facility construction, installation of equipment and software.

Prior to the installation of equipment, the construction work of FFWS facilities was made between July and September 2002. The second phase equipment and materials procured in Japan arrived at Casablanca Port on 10 March 2003, immediately stored in the storage house of ABHT in Marrakech until the start of the installation work in June 2003, as shown in Table 6.2.1.

8.1.1 Construction Work

The followings are the facilities constructed in 2002.

Constructed Facilities

Facility	Quantity	Location
Repeater Station House	2	Adrar Tazaina and Aoulouss
Antenna Mast (Japanese made steel mast: Panzermast)	6	Adrar Tazaina (2 masts), Aoulouss (2 masts), Amenzal (1 mast), Tourcht (1 mast)
Open Ditch for Grounding Wire	2	Aoulouss and Adrar Tazaina

A repeater station house with a space of 3 m (W) x 3m (L) x 2 m (H) was built on the mountain tops of Adrar Tazaina and Aoulouss, respectively. The drawing of the station house is also presented in Fig. 8.1.1.

A total of six metal masts called “Panzermast” were constructed as an antenna mast in Adrar Tazaina, Aoulouss, Amenzal and Tourcht. Excavation works of open ditches for grounding were also carried out around the repeater station houses of Adrar Tazaina and Aoulouss.

8.1.2 Installation of Equipment and software

The installation of the equipment was carried out jointly by four Japanese engineers dispatched from Japan Radio Co., Ltd., the supplier of the equipment and materials, and six employees from a Moroccan installation company under the supervision of the Study Team. The Japanese engineers and the Moroccan engineer and technicians formed four teams. Teams A and B were for installation of equipment, Team C was for software installation, and Team D was for adjustment of the data transmission system. Each team was composed of a Japanese engineer as a chief, two or three employees of the local company and an ABHT technician as an OJT (On the Job Trainee).

The installation was made at the following 11 sites:

Installation Sites of Pilot Project Phase II

Station/Post	Location/Organization
Master Information Center	ABHT
Repeater Stations	Adrar Tazaina, Aoulouss
Flood Watch Stations	Agouns, Tiourdiou, Amenzal, Tazzitount, Tourcht
Warning Related Stations/Post	Iraghf, Al Haouz Province, Ourika Caidat

(1) Grounding at Repeater Stations

A special attention was paid to the grounding work for the two repeater stations located on the high mountain tops that are exposed to frequent lightning. To secure the earth resistance as low as possible, long grounding copper wires were buried with earth resistance decrease mortar around the station houses and the antenna masts. As a result of hard excavation works of the rocky ground, the earth resistance became lower than 50 Ωof the target resistance at the both stations, as follws:

Results of Grounding

Repeater Station	Earth resistance (Pulse impedance)	Length of grounding wire
Adrar Tazaina	14 Ω	308 m
Aoulouss	15.8 Ω	400 m

(2) Telemetry Radio Network

70.325 MHz and 72.325 MHz radio frequencies that were officially given to DGH by ANRT are used for the telemetry radio network. Since the two frequencies are fortunately the same as those used in the radio propagation test in June 2001, the test results could be utilized fully for the installation.

Measurement of the radio signal strength and the Signal to Noise ratio (S/Nr) were also made for every span during the installation work to verify the performance of the radio circuit. The results are so good that the obtained values for all the spans cleared the design standard values, 30dB/µV of signal strength and 40dB of Signal to Noise ratio with sufficient margins. Consequently, it was judged that the telemetry radio network is excellent. A data sheet of the measurements is given in Table 8.1.1.

(3) Alarm Indicator

One of the most practical equipment in the second phase is an alarm indicator that was fixed on the wall of the landing of the stairs of ABHT. This alarm indicator that is connected to the radio equipment and the data processing server of the Master Information Center can sound three different alarms according to the food situation. The sound volume is loud enough for even the guardian staying outside the building to hear it. The three alarms correspond to commencement of rainfall, the pre-alert level and the alert level respectively. The tones are the more urging the more serious the situation is.

Once any flood watch station has recorded the first tipping (1 mm of rain) after the predefined non-rainfall duration, the station sends a signal to the radio equipment of the Master Information Center by the event-reporting function as explained in Subsection 6.4.2. Immediately the alarm indicator sounds the alarm of the commencement of rainfall. Similarly through the event-reporting function, an accession of water level to the pre-alert level is reported to the Master Information Center, resulting in the pre-alert alarm.

The alarm indicator can also sound the pre-alert and alert alarms, triggered by a signal from the server that compares with the pre-defined pre-alert and alert levels of water level and rainfall hydrological data received every 10 minutes from the flood watch stations.

(4) Radiotelephone Network for Warning Dissemination

Upgrading of the radiotelephone network for the warning dissemination was also achieved in this phase. A new radiotelephone with a 5-tone selective call system was installed at the Province and Ourika Caidat. The same selective call system was added to the radiotelephone installed at the warning post in the first phase.

The warning radio network uses the frequencies of the existing radio network of the province using the Sidi Bou Othmane Repeater Station located about 30 km north of Marrakech. The selective call system was added to the three stations to avoid unnecessary confusion with other radio stations of the province and to enable closed communication among the three. When one station calls the other by selecting its selective call code, a calling siren is blown at the receiving station. The assigned codes are presented as below:

Radio Stations for Warning Dissemination

Station	Selective call code	All station call code
Al Haouz Province	ST-1	
Ourika Caidat	ST-2	All
Iraghf Warning Post	ST-3	

(5) Replacement of Antenna at Warning Post

The radio propagation condition at Iragf Warning Post that is surrounded by mountains was critical, although communication with the other two stations was narrowly possible. Therefore, the existing non-directional antenna installed in the first phase was replaced by a 3-element Yagi antenna in this second phase, to secure stable communication by increasing the antenna gain.

8.1.3 Radio Interference Problems

Immediately after the installation of radio equipment at the Master Information Center of ABHT and the two repeater stations of Aoulouss and Adrar Tazaina, a series of communication tests and monitoring was commenced between ABHT and the repeater stations or between ABHT and/or the flood watch stations via the repeaters after the installation of the flood watch station. During these tests, however, two major interference waves were unexpectedly detected, though no interference had been observed during the radio propagation test in 2001 as described in Subsection 6.4.1. The interferences were so frequent and strong that they nearly killed the normal operation of the telemetry network. On Monday, 1 July 2003, almost half of data via the Aoulouss Repeater Station were lost due to the interferences.

(1) Investigation

An investigation was made on Tuesday, 2 July 2003 to collect more information on the interference waves. Signal strengths and tones of radio waves of frequencies between 70.325 and 72.325 MHz received at the Aoulouss Repeater Station were monitored about 7 hours between 1040 and 1800 hours. The investigation results are summarized as follow:

- Two major interferences were detected on the receiving frequency of 70.325 MHz for the repeater stations. One was voice communication in Portuguese probably for dispachig taxies, and the other was regular pulse noises like those for radio beacon or data transmission. Both the interference waves are strong enough to disturb the telemetry data reception of the Pilot Project.

Characteristics of Two Major Interference Radio Waves

Item	Wave 1	Wave 2
Content of Communication	Simplex voice communication in Portuguese with fading	Regular pulse noises like those of radio beacon or data communication
Wave Frequency and Location of Reception	70.325 MHz at the Aoulouss (N 31˚ 15.12', W 07˚ 38.75') and Adrar Tazaina (N 31˚ 15.48', W 07˚ 43.92') Repeater Stations	
Signal Strength	10 to 35 db/μv	6 to 28 db/μv

- No interference was detected on the transmission frequency of 72.325 MHz. This suggests a possibility to exchange of frequencies between the transmitter and the receiver as a solution of the interferences on the receiving frequency.
- Three neibouring frequencies of 70.800, 70.850 and 71.335 MHz seem to have been already used by other radio operators.

(a) Abnormal Long Distance Propagation

The two interferences seem to be caused by a phenomenon called "Abnormal Long Distance Propagation". The maximum propagation distance of VHF radio is usually from 40 to 100 km. This phenomenon can be accidentally caused in summer by the unstable Sporadic-E ionosphere and/or pipe-shaped atmosphere formed by constant high temperature, characterized by the followings:

- Occurs mainly in summer (from June to August in Morocco),
- Continues 5 to 20 minutes and disappears,
- Has strong signal level,
- Can reach 1,000 to 2,000 km, and
- Occurs mainly on low VHF frequency band.

(2) Countermeasures

If the interference waves are from foreign countries (at least the Portuguese voice communication is suspected of coming over the sea), even ANRT can not control them at all. If so, only one solution is to change the receiving frequency to escape from the interference waves.

The Study Team officially requested an investigation by ANRT through DGH at the beginning of July 2003. In the meantime the Study Team decided under consultation with ABHT, DGH, ANRT and JICA to exchange the frequencies between the receivers and the transmitters of all the stations because the Team could not wait for the investigation of ANRT, which was conducted between 23 and 24 July 2003. The exchange work was made successfully between 15 and 18 July 2003.

(a) Exchange of Receiving and Transmission Frequencies

The exchange of the frequencies between the receivers and the transmitters is the easiest and economical way to change the receiving frequency. This needed in practice just the exchange of the radio equipment between the repeater stations and the other stations only, but any change of the other equipment. It is also possible to totally change the frequencies to new frequencies that could be allocated by ANRT. However, it certainly requires more and more cost and time because new equipment including radio units and antenna systems for the new frequencies become necessary.

The radio equipment with the receiving frequency of 70.325 MHz and the transmission frequency of 72.325 MHz at the repeater stations were replaced by those of the flood watch stations with the receiving frequency of 72.325 MHz and the transmission frequency of 70.325 MHz. Accordingly those of ABHT and the flood watch stations were also changed as follows:

Frequency Assignment

Stations	Original		After exchange	
	Receiving Frequency	Transmission frequency	Receiving Frequency	Transmission frequency
Repeater Stations	70.325MHz	72.325MHz	72.325MHz	70.325MHz
ABHT and Flood watch stations	72.325MHz	70.325MHz	70.325MHz	72.325MHz

(b) Effectiveness of Exchange

The radio output power and signal strength of all the spans were checked again after the exchange. The results were as good as before, as presented in Table 8.1.1.

The new receiving frequency of 72.325MHz at the repeater stations is quite silent and clear. A small noise is found but it does not affect the data transmission. The data reception rate was greatly improved up to more than 99% as seen in Table 8.1.2 after the exchange, though data lacking probably caused by interference by lightning has been still observed.

(c) Investigation on Interference by ANRT

ANRT dispatched a radio monitoring vehicle to Marrakech to monitor radio waves on the two frequencies of 70.325MHz and 72.325MHz in the Ourika River Basin. Following suggestions by the JICA Study Team, the ANRT vehicle conducted monitoring at Oukaimedan for two days between 23 and 24 July 2003.

No survey report has been released by ANRT yet. According to ANRT, however, no radio waves except those of the Pilot Project were detected during the two day monitoring.

8.2 Technical Transfer Programs

A variety of technical transfer programs have been carried out during and after the installation work, so that personnel concerned could operate the installed system and do daily maintenance at least by themselves as soon as possible. These programs are summarized as follows:

Technical Transfer Programs

Program	Date	Trainees/Participants	Contents
Installation OJT	03/06/2003 to 14/07/2003	4 ABHT technicians and 5 station guardians	4 technicians from ABHT and 5 station guardians participated in the installation work on the job training basis.
Explanation on telemetry system	25/06/2003 to 27/06/2003	2 ABHT technicians	Explanation on telemetry system and repeater equipment was made at ABHT, Aoulouss and Tourcht.
Explanation on updated data processing software	13/07/2003 to 15/07/2003	4 ABHT technicians	Explanation on operation and maintenance of updated data processing software was made at ABHT.
Explanation on telemetry supervisory equipment	16/07/2003	4 ABHT technicians	Explanation on operation and maintenance of telemetry supervisory equipment was made at ABHT.
Explanation on radio equipment for warning dissemination	17/07/2003	4 ABHT technicians, radio operators of Province and Caidat and two guardians of warning post	Explanation on operation and maintenance of radio equipment for warning dissemination was made at Province, Caidat and warning post.
Station Guardian Training	22/07/2003	5 station guardians and 4 ABHT technicians	Guidance on telemetry system was made at Tazzitount Station.
Meeting on operation rule	31/07/2003	3 engineers and 4 technicians from ABHT	Discussions and confirmation on operation rule was made at ABHT.
Meeting on FFWS operation during 4 Aug. 2003 rainstorm	31/07/2003	2 engineers and 3 technicians from ABHT and a representative from Province and a guardian of warning post	Reviews on FFWS operation during 4 Aug. 2003 rainstorm was made at ABHT.
Global Simulation Drill (2)	26/08/2003	Organizations concerned	Communication and evacuation drills were conducted.
Inauguration ceremony	27/08/2003	Some 30 participants from organization concerned	Some 30 participants were invited to a explanation tour of Pilot Project visiting ABHT, Province, Tazzitount Station and warning Post.

8.2.1 Global Simulation Drill (2)

A global simulation drill including communication and evacuation drills was conducted on Tuesday, 26 August 2003 using the competed Pilot Project system. The drill procedure is almost the same as the one on 25 June 2002 under the Pilot Project Phase-I, except that ABHT did not have to collect hydrological data from the flood watch stations by radiotelephone because the completed telemetry system collects them automatically.

Although about 10 minutes was wasted in the transmission of the Flood Notice from ABHT to the Province due to a problem of the fax machine of the Province, the simulation drill was, on the whole, successful. The evacuation advice message could be broadcast at Iraght Warning Post about 17 minutes after the flood situation reached the alert level. Listening the evacuation message, some 80 voluntary participants moved smoothly to the predefined evacuation places.

(1) Communication Drill

The communication drill broke at 1705 hours with at a rainfall alarm at ABHT without any notice in advance. The assumed scenario was that the water levels exceed the pre-alert level at

1720 hours at Amenzal, Tazzitount and Tiourdiou, and then the alert level at 1730 hours at Amenzal and Tiourdiou, and that the flood situation returns so normal at 1740 hours that the cancellation message can be announced. These timings were determined in due consideration of conveniences of probable participants of the evacuation drill at Iraghf who were very busy in serving customers at their hotels, cafés and restaurants in the tourist high season.

A preparation meeting was held on the previous day at ABHT, inviting representatives of the organizations concerned. It was confirmed to employ the same routes for message diffusion as the global simulation drill in 2002 as shown in Fig. 7.4.3. The short-cut from the Province directly to the warning post was also confirmed under the bitter experience during the 4 August 2003 rainstorm explained in Subsection 8.4.

(a) Simulation Results

The consumed time in each procedure is tabulated in the following table, where the data of the drill in 2002 are also given together for comparison. The Pre Flood Notice (Flood Caution), Flood Notice (Evacuation Advice) and Cancellation messages took 8, 15 and 10 minutes respectively to reach the warning post after the occurrence of the corresponding events, 0 to 10 minutes earlier than the 2002 drill.

CONSUMED TIME IN EACH PROCEDURE IN SIMULATION DRILLS

(minutes)

Procedure	Date	Pre Flood Notice/ Flood Caution	Flood Notice/ Evacuation Advice	Cancellation
Announcement of Flood Notice by ABHT (Data collection, Decision making and Preparation of Message)	26 Aug. 2003	5	5	3
	25 June 2002	10	10	12
Distribution of Flood Notice Message by fax or telephone from ABHT to Province	26 Aug. 2003	2	9*	6*
	25 June 2002	1	3	1
Issuance of Flood Warning by Province (Decision-making)	26 Aug. 2003	0.5	0.5	0.5
	25 June 2002	6	1	1
Dissemination from Province to Warning Post	26 Aug. 2003	0.5	0.5	0.5
	25 June 2002	1	1	1
Total	26 Aug. 2003	8	15	10
	25 June 2002	18	15	15

* : Message was sent by telephone alternatively.

A great progress was achieved in the procedure of data collection, decision-making and preparation of message at ABHT, mainly owing to the introduction of the automatic data transmission. The consumed time in this procedure was shortened by 5 to 9 minutes, compared with the one in 2002.

On the contrary, more time was consumed for distribution of the Flood Notice from ABHT to the Province. ABHT firstly tried to send the message by fax, but in vain because the fax of the Province was busy at that time. The Province was sending the Flood Caution Message by fax to as many as seven organizations. The fax machine is so old that it takes two minutes to send it to one of the organizations, namely 14 minutes at least to the seven destinations. ABHT wasted as long as 9 minutes until they finally telephoned the Province.

(b) Evaluations and Recommendations

Since the stuff of the organizations concerned were getting more familiar with the procedures through a series of simulation drills and meetings, they could act very quickly and promptly. On the other hand, a problem of equipment was highlighted in this simulation. The congestion at the fax machine of Al Haouz Province delayed the reception of the ABHT's Flood Notice message.

As seen in Fig. 7.4.3, the Province must send flood warning messages by fax or telephone to 7 different organizations, and fax is preferred in principle from the reason of more accuracy. The only one fax machine at the Province is so old that it takes two minutes to send it to one of the organizations, namely 14 minutes at least to the seven destinations. In addition, the old fax must receive flood notice messages from ABHT and DPE. Moreover, another fax letters can possibly come into the fax too. Congestion of the fax machine is inevitable if this situation continues.

To solve this problem, the following measures are proposed:

(i) Additional Fax Machine

The first solution is to increase the sending and receiving capacity. It is desirable to introduce a simultaneous transmission fax that can simultaneously fax to many different destinations. CNP (Centre National des Previsons) of DMN in Casablanca has a fax machine of this kind to diffuse Special Meteorological Bulletins. Because of its high cost (about 100,000 DH), however, it might be unrealistic.

It is alternately proposed that not only the province but also all the other organizations involved in FFWS are equipped with two fax machines at least, one of which is for receiving and the other is for sending. Such congestion will be improved very much.

(ii) Use of Telephone with Fax

If it is difficult to add another fax machine, use of telephone might be allowed only for some destinations that do not need highly accurate information.

(2) Evacuation Drill

The evacuation drill was linked with the communication drill. Receiving the flood warnings from the Province, corresponding tape-recorded warning messages were immediately broadcast over the Iraghf area. Some 80 inhabitants, who voluntarily participated in the drill in spite of being busy in serving two or three hundreds of tourists, moved to the predefined evacuation places, accompanying two tourists.

The procedures of the evacuation activities were almost the same as those in 2002. Since the uppermost evacuation route of the 2002 drill was destroyed by debris flow in the 4 August 2003 rainstorm, the number of the evacuation groups was accordingly reduced to 2 from 3.

(a) Simulation Results

Thanks to cooperation of the local authorities and Royal Mounted Police, the evacuation drill was carried out steadily without any accidents and troubles. The consumed time in each procedure is tabulated in the following table, where the data of the drill in 2002 are also given together for comparison. The total number of the participants was 84 including 2 tourists. They took 5 to 7 minutes for gathering at the meeting places and 3 to 5 minutes for further moving to the evacuation places.

Summary Result of Evacuation Activities

Activities	Item		26 August 2003			25 June 2002
			Group 1	Group 2	Total	
Gathering at Meeting Point after Broadcasting of Flood Caution	Number of Participants	Inhabitants	58 (1)	25 (0)	83 (1)	129
		Tourists	0	1 (0)	1 (0)	13
		Total	58 (1)	26 (0)	84 (1)	142
	Consumed Time (minutes)		5	7	N/a	5
Evacuating from Meeting Point to Evacuation Place after Broadcasting of Evacuation Advice	Number of Participants	Inhabitants	50 (0)	8 (0)	58 (0)	104
		Tourists	0	2 (0)	2 (0)	12
		Total	50 (0)	10 (0)	60 (0)	116
	Consumed Time (minutes)		3	5	N/a	3

Note: Number in parentheses is the number of women.
Consumed time in the 2002 drill is the maximum time of the three groups.

(b) Evaluations and Recommendations

The number of the participants and the consumed time are both slightly worse than the records of the 2002 drill that was made in June just before the tourist season. Taking it into account that the 2003 drill was made during the high tourist season, the results should rather be considered positive, though a few problems were still identified as follows:

(i) Promotion of Participation of Women and Tourists

Although the Study Team made efforts to call for participation of more and more women and tourists by distributing a hundred of leaflets in advance, only two girls and two tourists participated in the evacuation drill.

(ii) Rewinding of Message Tapes

The tape-recorded warning messages start with a siren sound to attract people's attention to the following warning message. Therefore, the tapes should be kept rewound for preparing for the coming flood. However, the first message of pre-caution started directly with the message narration because the tape had not been rewound completely. This confused the evacuation participants.

(iii) Necessity of Evacuation Routes

The two evacuation routes are not in good condition for many people to move at one time. They are steep, slippery and then dangerous especially for women and tourists who are not familiar with the local conditions.

On the other hand, DREF is going to build some stairs to evacuation places in the Ourika Valley based on the strong proposition of the governor of Al Haouz Province. Such stairs have been are longed for by the inhabitants of Iraghf.

8.2.2 Inauguration Ceremony

An inauguration ceremony of the Pilot Project Phase-II, which were actually completed in July 2003, was held at ABHT on 27 August 2003, inviting some 20 representatives from the organizations concerned. This ceremony consisting of speeches and presentations and a site visit tour (aimed to firstly call for interests in and understandings of the Pilot Project among personnel concerned who are to operate and maintain the installed system. Journalists also participated in the ceremony and reported the Pilot Project in some newspapers.

8.3 Maintenance of Equipment

According to the contract between JICA and the Japanese supplier, Japan Radio Co., Ltd. (JRC), all the equipment of Pilot Project Phase-II are guaranteed by the supplier for one year from 16 January 2003. Within this guarantee period, any equipment that become out of order are to be repaired or replaced free of charge by the Japanese company. However, the Moroccan government must shoulder all repair costs immediately after then.

As the phase-I equipment, the phase-II equipment will be taken care of by ABHT who will be assisted by the DGH financially. According to DGH, they are preparing 200,000 DH, 80,000 DH up from the 120,000 DH of the 2003 contract, for the maintenance contract to be made with a local agent in 2004 for both the phase-I and II equipment.

8.4 Actual Operation During 4 August 2003 Storm

8.4.1 Introduction

The telemetry system completed at the end of July 2003 was handed over to ABHT practically on Monday, 4 August 2003. On that day, an exceptional heavy rainfall happened in the Ourika Valley. Fortunately dead nor injured casualties have been reported although debris flows occurred on many tributaries between Iraghf and Imin Tadrat.

Similar to the previous floods on 28 October 1999 in Section 4.5, 12 August 2001 in Section 4.6 and 14 June 2003 in Section 7.5, a close examination on what happened and on how the related organizations reacted during the rain storm was made to extract lessons for improvement of the FFWS.

8.4.2 Hydrological Conditions

(1) Rainfall

According to ABHT records, the exceptionally heavy rainfall, accompanied by thunder, lightening, and hail broke at the Tazzitount Station between 1740 and 1750 hours, as presented in Fig. 8.4.1. The rainfall continued in buckets about only 20 minutes, and then it lasted until about 2000 hours intermittently.

The rainstorm was very intensive in space as well as time. Fig. 8.4.2 gives spatial distribution of the total rainfalls observed at the flood watch stations in the Ourika basin. 50 mm of Tazzitount overwhelmed the others, followed by 31 mm of Tiourdiou. A high-intensity area was delineated around the Tazzitount Station as shown in the figure. This area coincides the areas where debris flows and slope failures took place during the rainstorm.

(a) Comparison of rainfalls Observed by Automatic and Manual Raingauges

This strong rainfall gave a precious opportunity to examine the reliability of tipping-bucket automatic rainfall gauges that were introduced in the Pilot Project. The following table compares the total rainfall quantities measured by the automatic gauges with those of the manual rainfall gauge that were still operational at the flood watch stations:

Comparison of Observed Rainfall by Station(mm)

Item	Rain Gauge	Tourcht	Tazzitount	Tourdiou	Amenzal	Agouns
Rainfall (mm)	Automatic (Pilot Project)	21	50	31	11	28
	Manual	20.5	91.5	25.8	14.9	21.3
Difference	Automatic – Manual	0.5	-41.5	5.2	-3.9	7.7

A big difference of 41.5mm is seen for the Tazzitount Station that is located in the center of the high intensity area, while the difference is not so significant at the other stations. At the Tazzitount Station, the automatic gauge recorded 50mm and the manual gauge data was as much as 91.5mm. The cause of this gap is unfortunately still unknown as discussed in Subsection 9.3.1

(2) River Discharge

The intensive rainfall area was not enough extensive to develop the river discharge significantly. The peak discharge was 101 m^3/s at Tazzitount and 147 m3/s at Aghbalau. The peak discharge at Tazzitount appeared at 1820 hours, only 20 minutes later after the strong rainfall, collecting discharges of many small tributaries pouring into the river from the eastern and western slopes.

(3) Debris Flow

Many tributaries between Iraghf and Imintadart poured an amount of debris as well as flood water onto the route P2017 and into the Ourika River as seen in Fig. 8.4.3. Judging from big rocks left on the road and the river bed, it seems natural that debris flow occurred on the tributaries. A few traces of small-scaled slope failures were seen along the road in this section.

As experienced in the past floods, the road was cut by debris at every tributary. About a hundred cars that left Setti Fadma were trapped by flood water and debris between Iraghf and Imintadart on their ways to escaping from the valley. The passengers were forced to spend the night in their cars until DPE cleared the road the next day. It was a miracle that these debris disasters generated no dead and injured, although a parked car was crushed by rocks and several houses were intruded by mud.

There is in Iraghf a café owner who happened to see debris flow just beside his café. According to him, the debris flow took place about only 15 minutes after it began to rain. This information is very precious for understanding the astonishing speed of debris flows that hardly allow enough time for the FFWS operation.

8.4.3 Activities of Organizations Concerned

(1) DMN Alert Message

DMN issued at 1100 hours in the morning an alert message of thunderstorms and showers with strong gusts over the areas including the High Atlas region of which validity was between 1400 and 1800 hours. This means the strong rainfall began just before the alert-message became void.

(2) ABHT

When an alarm rang from the alarm indicator installed at the wall of the pace between 1740 and 1750 hours to notice the commencement of rainfall at the Tazzitount Station, an engineer and a technician were luckily in the Master Information Center room. They immediately knew the commencement of the rainfall at Tazzitount, seeing the flood information display of 1750 hours on the Client PC. At 1800 hours they found that rainfall reached the alert level through the renewed display and an alert sound form the alarm indicator. Since they could not use the fax machine that were locked for exclusive use of the secretary of the director, they informed the province, DGH, DMN, DPE, DRE, etc. of a flood notice regarding the occurrence of the exceptional rainfall by telephone. They continued to watch the hydrological situation staying in the room until around 2120 hours, when they announced the cancellation of the flood notice by telephone.

It looks like ABHT could response to the exceptional rainfall properly on the surface except that they could not use the fax machine. If closely examined, however, two major problems can be extracted. The first one is a mechanical problem, namely data lacking due to interference by lightning. The second one is an organizational one. They could not communicate with the flood watch stations until the radio operator who has the only one key of the radio room came back around 1900 hours for the regular communication. It is very difficult to avoid the first problem, but the second problem is too miserable. If they had could communicated with the Tazzitount Station at 1750 hours, they could have informed 10 minutes earlier the related organizations of the occurrence of the exceptional rainfall, as follows:

(a) Interference by lightning

Fig. 8.4.4 gives a copy of the rainfall table on the computer display at 2100 hours of the day. A symbol “---“ in the table denotes that the data was missing. For the two stations of Tazzitount and Torcht that are relayed by the Aoulouss Repeater Station, rainfall intensity and accumulated rainfall data of 1740 hours are lacking. Intensity data of 1750 are also missing, but this was influence of the lacking of the previous data (Rainfall intensity is calculated by subtracting the previous accumulated rainfall from the current accumulated rainfall). Data themselves were transmitted to the system as understood from the fact that the accumulated rainfall data values are really in the table. Similar data lacking occurred at 1800 hours for the three stations relayed by the Adrar Tazaina Repeater Station.

Since data at the problem times are all stored normally in the RTUs (Remote Terminal Units) of the flood watch stations, it is natural to guess that the lacking was occurred during the data transmission, probably by lightning. Many people remember that it was thundering and lightening before and during the rainfall. Intermittent abnormal noises like thunder were also heart from the radio equipment of the telemetry system in the Information Center room.

Such interference by lightning is inevitable unfortunately as far as the system relies on the 70 MHz band, as explained in Subsection 9.3.1. This is a disadvantage of the low

VHF band radio network. Summer storms in the Atlas Region are usually accompanied by thunder and lightning. Therefore, it should be taken granted that data lacking is possible at times of storms. To minimize the influence of this disadvantage, communication with the flood watch stations through the existing radiotelephone is very important. Once data lacking is found, the stations should be immediately contacted by radiotelephone to ask them to read the non-transmitted data from the RTUs.

(b) Permanent System and Access to Radio Room

The current permanence system of ABHT is so mild that the radio operator on duty can leave the room except times of the regular communication with the flood watch stations. Similar to the case of the 14 June 2003 flood, the radio operator of the day was absent at the beginning of the rainstorm. He came back to ABHT for the regular communication just before 1900 hours, about one hour later.

Luckily there were an engineer and a technician practicing the new equipment in the Master Information Center room at that time. However, they could not utilize their good luck 100%. They could diffuse the flood notice to the related organizations, but they could not collect more information directly from the flood watch stations only from a poor reason that they could not open the radio room. If they had contacted the Tazzitount station to inquire the lacking data, they could have diffuse the notice 10 minutes earlier. The 10 minutes is not definitely short, especially for debris flows and flash floods of tributaries like those generated by this rainstorm.

(3) Al Haouz Province

Since the governor was on leave, the secretary general was a supreme commander of disaster management on that day. Around 1800 hours he was informed of the occurrence of the strong rainstorm in the Ourika Valley by ABHT. Immediately he diffused a command to evacuate people to local authorities, Royal Mounted Police, Civil Protection, Auxiliary Force, DPE, etc by telephone. According to the general secretary, he gave a direction to broadcast the evacuation advice message at the Iraghf Warning Post to the Khalifa of Ourika Caidat. To supervise all the operations on site, he departed for the valley and arrive at Iraghf around 2100 hours.

(4) Ourika Caidat

The Ourika Caidat was also on leave. His Khalifa played as the substitute. He was informed of the occurrence of the strong rainfall by the Chaikh of Acheg Douar located near the Tourcht Station through mobile phone around 1800 hours. Immediately he telephoned the super caidat, chaikhs and macadems to inform the rainfall and to collect further information on the rainstorm from them. He also received a telephone call from the secretary general of the province. He ordered the guardian of the Iraghf Warning Post to manage the situation by himself.

(5) Iraghf Warning Post

There were some one thousand tourists and some one hundred tourist cars at the Iraghf area. It began to rain just before 1800 hours with thunder, lightening and hail. The heavy rainfall continued about half an hour and then weakened but lasted until 2100 hours intermittently.

Since the radiotelephone of the warning post was not operational due to a problem of the repeater station at Sidi Boatmane, the operator of the Iraghf Warning Post tried to telephone the province around 1800 hours, but no answer returned. In the heavy rain most of the tourist cars left Iraghf to escape from the valley. Hundreds of hotel guests began to evacuate to the houses on the mild mountain slope behind the hotel area under the guidance of the inhabitants through the evacuation routes designated in the Global Simulation Drill in 2002.

The guardian of the warning post was at a loss what to do, because he was not given any directions yet. Some inhabitants crowded to the post, calling for any messages regarding the flood situation. It was after 1830 hours, when most of the tourists and inhabitants evacuated already, that the guardian broadcast the warning cancellation message tape, encouraged by the direction by the Khalifa. It is strange that the cancellation message was broadcast directly before the flood caution or the evacuation advice messages would be broadcast. According to the guardian, he did not stimulate the people so much and selected the mildest message.

CHAPTER 9. EVALUATION OF PILOT PROJECT

9.1 Introduction

As described in the previous chapters, the Pilot Project was implemented in two phases. The first phase was completed in December 2001, and immediately its experimental operation started and continued about one and half years until when the second phase was completed in July 2003. Unfortunately the experimental operation of the full automatic telemetry system that was finally completed in the second phase was as short as one and half months from the beginning of August to mid-September 2003.

During these periods, the JICA Study Team supported and monitored the experimental operation in Morocco and even from Japan while the team was back in Japan. This chapter describes the evaluation of the Pilot Project based on results of the monitoring activities including a variety of trainings and simulation drills. Finally the draft master plan is modified and updated in the following chapter in consideration of the evaluation results.

9.2 Criteria of Evaluation

9.2.1 Objective of Evaluation

The objective of the evaluation of the Plot Project is to find, through the evaluation, hints for improvement and updating of the darft master plan that was proposed in Chapter 5.

9.2.2 Criteria of Evaluation

The Pilot Project is a so-called man and machine system that is composed of machines (equipment) and manual operation (guidelines). The evaluation is made firstly on the two parts respectively, and then on the whole project as a total system. The criterion of the evaluation, which is commonly applied for the three is adequacy in terms of effectiveness against disasters and sustainability. The following table presents the three criteria and main considerations for the evaluation:

Three Criteria and Main Considerations

Criteria	Main Considerations
Adequacy of Equipment	• Do the equipment function properly during floods (Effectiveness)? • Are the equipment kept operational (Sustainability)?
Adequacy of Guidelines	• Are operations according to the guidelines effective against floods (Effectiveness)? • Are the guidelines accepted by personnel concerned (Sustainability)?
Adequacy as Total System	• Is the system effective for reducing disaster damages (Effectiveness) • Is the system technically and financially sustainable (Sustainability)?

9.3 Evaluation

9.3.1 Adequacy of Equipment

(1) Effectiveness of Equipment against Disasters

Effectiveness of the Pilot Project equipment can be evaluated by examining their actual performances during past disasters. Table 9.3.1 presents performances of the equipment and the manual operations during the two flood events, the 14 June 2003 flood and the 4 August 2003 rainstorm.

According to the table, the equipment generally functioned properly. Especially, effects of the telemetry system that was completed fully in July 2003 at last was magnificent. During the 4 August 2003 rainstorm, the automatic system made ABHT aware of the outbreak of the intensive rainstorm by sounding alarms, and provided rainfall and water level data every 10 minutes on real-time basis, though a few issues are still remaining unsolved.

(a) Effects of Telemetry System

Effects of the telemetry system are obvious. The telemetry system can automatically measure rainfall and water level at the flood watch stations and transmit them to the Master Information Center of ABHT in Marrakech. The automatic system can not only alert ABHT by sounding alarms but also process the raw hydrological data into visualized more understandable information, which is accessible from the Monitoring Stations of DGH, DPE Al Haouz,, Al Haouz Province and Ourika Caidat.

The full automatic system is revolutionary in that it excluded any possibilities of troubles caused by human errors, which happened often even during the Pilot Project and may happen in future too. The observed data are delivered to ABHT from the rainfall and water level gauges of the flood watch stations within two minutes at longest. Thus the telemetry system contributed greatly to the enhancement of the reliability of the FFWS in terms of accuracy and time-shortening. According to an ABHT technician, during the 4 August 2003 rainstorm ABHT could for the first time inform the occurrence of the heavy rainfall to the Province earlier than the local authorities that used to inform earlier than ABHT.

(b) Issues Identified during 8 August 2003 Rainstorm

While the telemetry system executed its power, the following two issues were identified during the 8 August 2003 rainstorm.

- Big Gap between Rainfalls of Automatic and Manual Gauges at Tazzitount Station
- Interference of Lightning to Data Transmission

(i) Big Gap between Automatic and Manual Rain Gauges

As discussed in Subsection 8.4.2, a big gap was found between the rainfall quantities measured by the automatic and manual rain gauges during the 4 August 2003 rainstorm. The manual gauge data was as much as 91.5 mm at the Tazzitount Station, while the automatic gauge recorded only 50mm. As seen in the following table, such a big difference was not found during the other floods.

Comparison of Rainfall Quantities by Automatic and Manual Gauges during Heavy Rainfalls Exceeding Alert Level

Date	Station	Rainfall (mm)		Difference	
		Automatic	Manual	(mm)	(%)
2003/06/14	Agouns	50	43.4	6.6	13
2003/08/04	Tourcht	21	20.5	0.5	2
Ditto	Agouns	28	21.3	6.7	24
Ditto	Tiourdiou	31	25.8	5.2	17
Ditto	**Tazzitount**	**50**	**91.5**	**-41.5**	**-83**
2003/08/09	Tazztount	22	21	1.0	5
2003/08/12	Agouns	8	7.4	0.6	8

Two possibilities are conceived as a cause of the big gap. The first one is that the automatic gauge could not receive correctly such heavy rainfall due to choking with dusts and leaves or due to a capacity problem of the gauge. The second one is that the manual observation data was wrong. However, there is no conclusive evidence available to determine the cause, as explained below.

Since choking of the automatic tipping-bucket gauge with dusts and/or leaves seemed the most probable, the gauge was checked immediately after the rainstorm. The cylinder outer cover was removed, but no obstacles such as dusts and leaves were found inside. Secondly the capacity of the automatic gauge was suspected. To verify this possibility, the Study Team referred to the gauge manufacturer for the capacity. The manufacturer who had kept no data of such capacity, kindly conducted a test to check the function of the automatic tipping-bucket gauge under artificial extraordinary rainfall with high intensity of 50 mm in 10 minutes (corresponding to 300 mm/hr). As a result, the test proved the excellent function of the rain gauge, which could measure the high intensity rainfall with an accuracy of 98%. If the automatic rain gauge of the Tazzitount Station executed the same function during the rainstorm, the observed data of 50 mm must be correct.

Since the manual observation is very simple, it is generally difficult to think that the station guardian made any error in measuring the rainfall. There is no clue available to verify this unfortunately.

(ii) Interference of Lightning to Data Transmission

As described in Section 8.4.3, lightning affected the data transmission system during the 4 August 2003 rainstorm. Data lacking took place just before and at the beginning of the rainfall as shown in Fig. 8.4.4.

Lightning impulses are a sort of radio wave of which frequencies are generally from 150KHz to 100MHz. The 70MHz band used in the Pilot Project is affected by lightning more than the other higher VHF bands. When the telemetry data transmission meets lightning by chance, the telemetry data might be lost. It might make the problem more difficult that the two repeater stations are located on the high mountain tops that thunderclouds pass over very often in summer. This problem is inevitable as long as the low VHF band is used. The low VHF band (70MHz band) is an ideal frequency for the radio propagation in mountainous areas, though it is more susceptible to abnormal long distance interferences and impulses from lightning especially in summer.

The telemetry system calls the stations again, two more times at the maximum, if abnormal data is given from the station. To reduce opportunities of data lacking, it is recommended to increase the calling, changing the setting of the maximum limit from two times to seven times of the limit of the system. In addition, it is the turn of the manual backup system to minimize the influence of this disadvantage with the present system. Communication with the flood watch stations through the existing radiotelephone is very useful. Once data lacking is found, the stations should be immediately contacted by radiotelephone to ask them to read the non-transmitted data from the RTUs.

(2) Sustainability of Equipment

To secure sustainability, durability on other words, the equipment should be free from chronic or fatal problems. Even if certain equipment are broken down, they must be repaired or replaced with correct ones as soon as possible. From this point of view, information on troubles of the Pilot Project equipment and their repairs was collected and seven major troubles were identified as shown in Table 9.3.2, and then summarized below:

Major Troubles of Equipment

Troubled Equipment	Stations	Trouble	Cause of Trouble	Measure
Connection between Server and Client PC	Master Information Center (ABHT)	No connection	Mis-operation of software	Restoration by Sohime under direction of JRC
Switching Hub	Master Information Center (ABHT)	Temporal failure	High temperature	Naturally restored
RTU (Remote Terminal Unit)	Agouns, Amenzal	Breakdown of DC/CD Converter	Over-voltage by lightning	Replacement of three circuits with newly modified ones by Study Team (JRC).
DC UPS	Iraghf Warning Post	No charging	Low unstable power supply	Provision of a automatic voltage regulator by Study Team
Metal Mast	Iraghf Warning Post	Crushed by debris	Debris flow during 4 August 2003 rainstorm	Replacement of the metal mast with two concrete masts by Study Team
Radiotelephone	Iraghf Warning Post	Unstable communication	Low signal strength	Replacement of the non-directional antenna with a directional anntena by Study Team

Sohime : The Moroccan company that signed the maintenance contract of the Pilot Project equipment with DGH.
JRC: Japan Radio Co., Ltd, the Japanese supplier of the Pilot Project equipment

These troubles were not so technically difficult, except for those of the RTUs that required special treatment of the Japanese equipment supplier. All the troubles were solved within a month, and neither chronic nor fatal problem was found in the Pilot Project.

Regarding the RTU problems, the influence of lightning was probably underestimated in designing the RTUs. Although the guarantee period of the equipment was over about one year ago, the equipment supplier, JRC immediately coped with the problem. They complimentarily developed and provided new three circuit boards that are strong against impulses of lightning.

Troubles of the switching hub of the ABHT server and the DC UPS and the metal mast of the warning post were caused under unexpected severe environments such as a non-air-conditioned room, unstable low voltage power supply and debris flow. They become precious lessons for designing of the Master Plan.

Since most of the troubles were solved by the JICA Study Team who happened to stay in Marrakech luckily at the trouble times, the capacity of the organizations concerned for handling such troubles has not been practically challenged yet.

9.3.2 Adequacy of Guidelines

(1) Effectiveness of Guidelines

The effectiveness of the guidelines for the operation of the Pilot Project proposed in Section 7.2 can be measured by performances during actual floods like that of the equipment if the operation follows the guidelines.

On the other hand, actions to be made by the principle organizations are stipulated in the proposed guidelines according to the flood phases that were defined by the DMN messages and the ABHT flood notices. The ABHT flood notices are further decided by whether the hydrological situation (rainfall and/or water level) exceeds the pre-defined pre-alert and alert levels. Namely the DMN messages and the predefined values of the pre-alert and alert levels are the most important indicators for the actions of the principle organizations under the proposed guidelines, worthy of being examined using hydrological data accumulated during the experimental operation.

In accordance with the above considerations, the actual performances of the manual operations during the same floods were evaluated in Table 9.3.1. DMN messages were collected to compare with the actual flood conditions, and the frequency how often the Pre-alert and Alert Levels were reached was investigated using the database stored in the data processing server at the Master Information Center of ABHT.

As a result, the effectiveness of the proposed guidelines during the actual floods has not been proven out unfortunately, mainly due to simple errors that should be solved prior to discussions on the guidelines. Although the effectiveness was confirmed tentatively in the simulation drills, the real evaluation is postponed to the next flood. The DMN messages are not so accurate but still worthy of relying on. As far as 21-month hydrological data are concerned, no reason is found to change the Pre-alert and/or Alert Level values of rainfall and water level. It can be concluded that the current guidelines can be continued until any specific problem on them is identified.

(a) Performances during Actual Floods

Table 9.3.1 includes the evaluation of the manual operations by the principle organizations during the two flood events, the 14 June 2003 flood and the 4 August 2003 rainstorm.

Generally the manual operations were evaluated lower than that of the equipment. Many simple mistakes were identified almost for every subsystem. For example, ABHT did not know the DMN message fax, there was no radio operator at ABHT when called by the flood watch stations, the radio room of ABHT was locked and inaccessible, the dissemination route of warnings was wrong, the flood information display was not referred by the monitoring stations, and so on. These mistakes were mostly due to insufficient understandings of the guidelines, imperfection of the permanence system of ABHT, not generated from the guidelines themselves.

On the contrary to the guidelines that are calling for inter-agency communication for information exchange, efforts to collect more information on floods were insufficient among the organizations. In particular, ABHT is negative in this point. ABHT could have collected information from DMN, DPE and the Province during the 4 August 2003 rainstorm besides the distribution of the flood notices. Shortage of communication tools (telephone & Fax) as well as personnel might be discouraging ABHT.

(b) DMN Messages and Definition of Hydrological Indicators of Pre-alert and Alert Levels

(i) Accuracy of DMN Message

Once a DMN Pre-alert or an Alert Message is issued, the Preparatory Phase breaks according to the proposed guidelines. The related organizations are to strengthen the preparedness against the coming flood, for example by mobilizing a FFWS team in ABHT. However, it is true that there are complaints about the accuracy of the DMN messages among the organizations.

The following table gives a list of DMN messages issued in July and August 2003 together with descriptions of the actual flood conditions. DMN issued in total 8 Pre-alert and Alert messages for the areas including the Ourika Valley. 3 messages of the 8 messages guessed right flood situations exceeding the pre-alert level at least, but the other 5 messages failed.

DMN Message and Actual Flood Condition

Date and Time of Issuance	Pre-alert /Alert	Duration of Validity	Actual Flood Condition
2003/7/17 1540 hours	Alert	1620 to 2100 hours	No rain
2003/7/18 1200 hours	Pre-alert	1500 to 2030 hours	Below pre-alert level
2003/7/18 1500 hours	Alert	1530 to 2100 hours	Below pre-alert level
2003/7/18 1837 hours	Alert	1840 to 2100 hours	Below pre-alert level
2003/7/23 1440 hours	Alert	1450 to 2000 hours	Below pre-alert level
2003/8/4 1130 hours	Pre-alert	1400 to 1800 hours	Over Alert level
2003/8/6 1430 hours	Alert	1430 to 2200 hours	Over Pre-alert Level
2003/8/10 1540 hours	Alert	1540 to 2200 hours	Over Pre-alert Level

DMN has been making efforts to enhance the accuracy of the weather forecasting, but that for a localized area, especially in the High Atlas region still remains to be improved a lot. In the above table, more than half of the messages failed. On the contrary, however, it can be said that almost half is correct, too. The messages seem worthy of listening to if about 50% of accuracy is assured.

(ii) Frequency of Exceeding Pre-alert and Alert Levels

The Pre-alert and Alert Levels are indicators of the Pre River Flood Notice and River Flood Notice respectively that are to be announced by ABHT. If they are set the lower, these notices are announced the more frequently. Such frequent notices might get the organizations tired. The higher, the less time is given to the organizations for preparation against the flood. If too high, a flood could be missed.

In this sense, it is very important to know how often rainfall and/or water level reached the Pre-alert and Alert Levels. Table 9.3.3 gives dates when rainfall and/or water level reached the Pre-alert and Alert Levels pre-defined in Subsection 7.2.2.

In the data period of 21 months the Pre-alert Level was reached 12 days and the Alert Level 4 days, corresponding to 6.9 and 2.3 days/year respectively. The frequencies of 6.9 and 2.3 days/year do are not too high to get the organizations tired. Moreover, the two floods of 14 June 2003 and 4 August 2003 that generated a certain damage reached the Alert level. This means that the proposed guidelines could detect the harmful floods. The current Pre-alert and Alert Levels could be considered adequate, although it seems bold to definitely judge based on the data of the short period of 21 months.

Number of Days Reaching Pre-alert and/or Alert Levels

Cause	Pre-alert	Alert
Rainfall	12	4
Water Level	3	0
Total	12	4

Note: Data period is about 21 months from Dec. 2001 to Sep. 2003

(2) Sustainability of Guidelines

The sustainability of the guidelines depends upon how much the guidelines were accepted by the personnel concerned. The Study Team has made every effort to explain to, discuss and consult with them about the guidelines through meetings and simulation drills. The organizations concerned also have been cooperating with the Study Team in every occasion. As seen in the simple errors experienced in the recent floods, however, the guidelines have not yet soaked into the organizations concerned completely. Further training programs and simulation drills are necessary.

The effect of the simulation drills is beyond question. As the organizations concerned acted more quickly in every simulation drill, their understandings were improved very much. As far as understood from the performances during the actual floods, however, it is true that their actual reactions are still far from satisfactory levels. This is probably not only due to individual problems of the personnel concerned but also due to organizational problems including those of tools (telephone, fax) and the permanence system.

9.3.3 Adequacy as Total System

(1) Effectiveness of Total System

Since the completed total system was not operated appropriately during the actual floods as discussed in the previous subsection, the effectiveness of the total system has not been verified yet. If the total system is operated as properly as the simulation drills, however, the necessary consecutive procedures from data collection to evacuation can be completed within about 20 minutes, l0 minutes less than the target of the Master Plan. Even if in a real situation the procedures are not undertaken as smoothly as the simulation drills, the 10 minute margin is still considered significantly large. It is no exaggeration to say that the simulation result showed a high possibility of the pilot FFWS.

On the other hand some limitations of not only the Pilot Project but also this non-structural measure, FFWS itself were revealed by the recent floods, as feared previously. Flash floods and debris flows from tributaries caused by local rainfall are too fast for the FFWS. They do not allow enough time for the operation of the FFWS. Although no causality was reported fortunately in the Pilot Project, the treatment of visitors by car remains an issue of disaster prevention in this region. There are still many problems that cannot be solved by FFWS alone.

(2) Sustainability of Total System

To assure the sustainable operation of the pilot FFWS, essential is machinery to support the FFWS institutionally, financially and technically. Since the Study Team executed considerable parts of those supports in the Pilot Project, such machinery has not been completed yet among the organizations concerned. Some movements towards the creation of the machinery are advancing slowly but steadily.

The greatest achievement of these movements is the signing of a convention on the operation and maintenance of the pilot FFWS that was made in November 2004. The remaining steps are to create a coordination committee and to execute responsibilities as stipulated in the convention.

(a) Signing of Convention

The JICA Study Team has been advising the Province and ABHT to conclude a convention on the operation and maintenance of the pilot FFWS among the related organizations since the first phase. Al Haouz Province, ABHT and DPE Al Haouz finally signed the convention on 7 November 2003, witnessed by the JICA Study Team and the JICA Advisory Committee.

(b) Responsibilities of Province and ABHT

This convention stipulates concretely the responsibilities of Al Haoz Province and ABHT in relation to the operation and maintenance of the pilot FFWS, as follows:

Responsibilities of Province and ABHT

Al Haouz Province	ABHT
• Create a committee of FFWS operation and follow-up; • Be in charge of FFWS operation as far as it is concerned, regarding decision making, issuance and dissemination of flood warnings and evacuation; • Supervise and assist the Ourika Caïdat and Igharf Warning Post; and • Assure the daily maintenance and the protection of the equipment under its jurisdiction and inform the ABHT about any equipment breakdown necessitating its intervention.	• Be in charge of FFWS operation as far as it is concerned, regarding data observation, collection, processing and analysis, forecasting and issuance of flood notices; • Assure the daily maintenance and the protection of the equipment installed in the ABHT and in the hydrological stations; • Assure preventive and regular maintenance of all the equipment installed within the framework of the Pilot Project; and • Assure the correctional maintenance of all the equipment (the reparation or the replacing of all broken down equipment).

(a) Creation of Committee

The convention also stipulates creation of a committee for operation and follow-up of the pilot FFWS, which is to be presided over by the governor of the province. The committee members are Al Haouz Province, ABHT, DPE Al Haouz, DREF High Atlas, DMN Marrakech, Civil Protection of Tahanaout and Royal Mounted Police of Tahanaout, but the governor as the chairman can invite any other organization if necessary. ABHT is to assure the committee secretariat.

9.3.4 Conclusion

Based on the above discussions, the evaluation results are summarized as follows:

Summary of Evaluation

Criteria	Considerations	Evaluation	Issues
Adequacy of Equipment	Effectiveness	B	• Measures against lightning should be considered.
	Sustainability	B	• Maintenance works should be assured.
Adequacy of Guidelines	Effectiveness	B in simulation drills but practically unknown	• The guidelines of which effectiveness was confirmed tentatively in the simulation drills should be examined in actual floods.
	Sustainability	C	• Strengthening of permanence system and provision of necessary equipment is indispensable. • Training programs and simulation drills should be executed regularly.
Adequacy of Total System	Effectiveness	B	• Effectiveness against flash flood debris flows of tributaries is insufficient • There are still many problems that cannot be solved by FFWS alone..
	Sustainability	B	• Machinery to support the pilot FFWS is indispensable.

A: excellent, B: good , C: fair, D: poor

CHAPTER 10. MODIFICATION OF MASTER PLAN

10.1 Introduction

The draft Master Plan that was tentatively proposed in April 2001 as described in Chapter 5 is modified and updated in this chapter. In these two and half years after the proposition of the draft Master Plan in the Interim Report 2, the Pilot Project, a part of the Master Plan was implemented step-wisely, immediately followed by its experimental operation. DRHT that was supposed to be an execution agency of the Master Plan was practically transformed into ABHT (Basin Agency) in this period in accordance with the national policy of decentralization.

In modifying the draft Master Plan, not only the evaluation results of the Pilot Project in Chapter 9, but also some changes during the two and half years relevant to the Master Plan should be taken into consideration. Points of the modification are summarized in the following table:

Points of Modification

Item		Modification	Reason for Modification
Basic Condition of Master Plan	Target Completion Year	Long term implementation is considered as an alternative.	• More severe financial conditions are expected for implementation of Master Plan in relation to transition of DRHT to ABHT.
Modification of Subsystem	Hydrological Observation and Data Collection Subsystem	Redesigning of radio network for telemetry system is made.	• The radial network established in the Pilot Project should be utilized for the telemetry network of Master Plan.
	Diffusion of Flood Warnings	Semi-automatic system is introduced.	• Cost reduction is desirable. • Potential of semi-automatic system was verified in Pilot Project.
Modification of Operation and Maintenance Plan (Strengthening of Institutional Plan)		Creation of a coordination committee is proposed.	• To assure sustainability of the FFWS, necessity of such a committee was revealed through Pilot Project. • Such a committee has been proposed in in the National Master Plan against Flood by DGH.
		Strengthening of Permanence duty is emphasized.	• Failures due to the present loose permanence duty were revealed in Pilot Project.
		Necessity of explanation and training (simulation drills) for full understanding and improvement of FFWS is emphasized..	• Failures due to poor understandings of FFWS procedures were revealed in Pilot Project.
		Necessity of interactive analysis with DMN is emphasized.	• Importance of weather forecast was recognized through Pilot Project.
		Importance of information from local authorities is emphasized.	• Importance of information from local authorities was reconfirmed through Pilot Project.
		Importance of evaluation and grade-up applying management cycle is emphasized.	• Necessity of this management cycle is a must for sustainable development of FFWS.
		Importance of participation of inhabitants and tourism related Industries is emphasized.	• Importance of cooperation of local inhabitants was realized again through the Pilot Project.
Necessity of comprehensive approach for disaster prevention		Comprehensive approach including a variety of structural and nonstructural measures is recommended.	• Limitation of FFWS and necessity of comprehensive approach was reconfirmed through Pilot Project.

10.2 Modification of Master Plan

10.2.1 Target Completion Year of Master Plan

In the draft Master Plan, the target completion year was set at 2007, assuming 5 years of implementation period immediately after the completion of this Study in 2002 (This study period was later extended to 2004), as discussed in Subsection 5.1.2. Behind this setting there was an expectation of strong initiatives of DGH for financing like the similar project for the Ouergha River Basin.

However, the financial conditions of ABHT that is expected to be the executive organization of the Master Plan are becoming severer than at the time of the draft Master Plan, especially upon the transition from DRHT to the more independent basin agency of its superior organization, DGH. The cancellation of the telemetry project in the Oum Er Rbia may be a good example to understand such severe financial conditions of the basin agencies.

Under these situations, ABHT is alternatively planning to implement the Master Plan in a longer period so that the annual disbursement could be reduced. In due consideration of the financial conditions and the views of ABHT, a case of 10 years of implementation period is additionally proposed as a more realistic scenario. 10 years might be the longest limit as the implementation period of the telecommunication sector where technical innovation is so dynamic.

If the implementation is commenced in 2005, immediately after the completion of this Study, the target completion year is 2009 for the 5-year implementation and 2013 for 10-year implementation respectively.

Target Completion Year

Alternative	Implementation Period	Completion Year
Alternative-1	5 years	2009
Alternative-2	10 years	2014

10.2.2 Modification of Subsystem

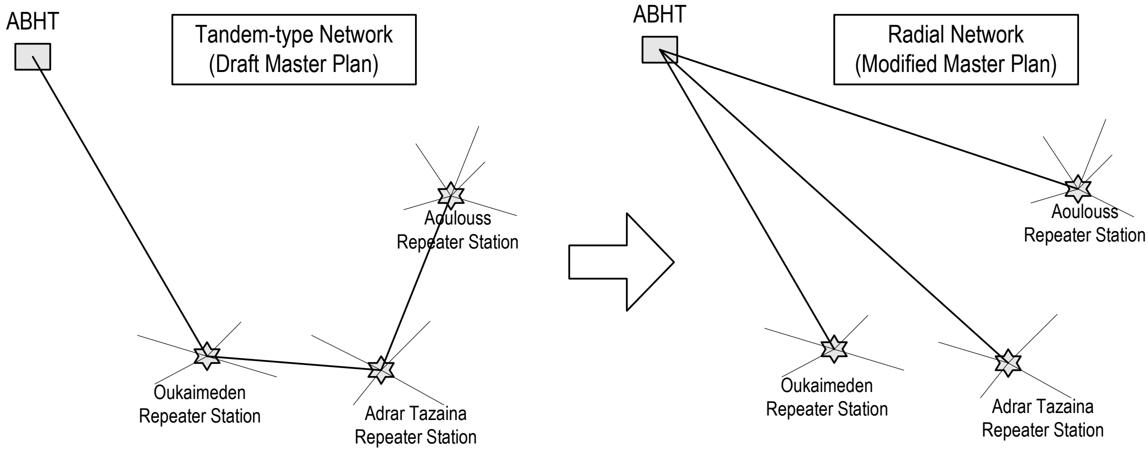
The telemetry radio network of the Hydrological Observation and Data Collection subsystem is updated by incorporating the existing network installed in the Pilot Project. To reduce the cost for the Warning Dissemination subsystem, a semi-automatic indirect warning dissemination system of which potential was verified through the Pilot Project is introduced to the Ourika Valley in place of the directly remote-controlled system proposed in the draft Master Plan.

(1) Redesigning of Telemetry Network

In the draft Master Plan a VHF radio network was designed assuming a frequency band of 88MHz, based on radio circuit calculations using topographical profiles. The network includes five repeater stations for the 20 flood watch stations as shown in Fig. 5.4.1. In the Pilot Project on the other hand, a radial network with two repeater stations of Adrar Tazaina and Aoulouss was finally established in July 2003, modifying the telemetry network of the draft master plan as shown in Fig. 6.4.2.

The Adrar Tazaina Repeater Station and the Aoulouss Repeater Station (called "Setti Fadma Repeater Station" in draft Master Plan) were to be further relayed by the Oukaimedan Station in the old master plan. The tandem-type network was afterward modified in the Pilot Project into a radial network that is generally more reliable, based on radio propagation tests using the same frequencies of 70.325 MHz and 72.025 MHz as officially allocated by ANRT later for the project.

It is reasonable for the new Master Plan to follow the current network of the Pilot Project as much as possible. The existing parts connected to the two existing repeater stations should be used in the Master Plan as they as now. The modified network is given in Fig. 10.2.1.



Modification of Telemetry Network

(2) Redesigning of Warning Dissemination Subsystem

In the Pilot Project, ABHT, substantially being supported by DGH, is in principle not only technically but also financially maintaining all the Pilot Project equipment including those for warning dissemination, though the province/prefecture is in charge of their operation. According to DGH, DGH will continue to financially assist ABHT in the maintenance contract for the Pilot Project from the reason why DGH signed the agreement for the Pilot Project equipment with JICA, but no pledge has been made by DGH for the Master Plan.

Since ABHT is getting more independent of DGH in accordance with the Water Law, it becomes more difficult for ABHT to receive a subsidy from DGH fully for the maintenance of the Master Plan too. The province /prefecture of which financial conditions are severer, will be also required to bear a certain part of the maintenance cost that ABHT is now paying for in the Pilot Projects. In terms of ownership of the equipment, such financial contribution of the local authority is desirable.

The problem is the financial capacities of the province /prefecture. As Al Haouz Province failed in the Pilot Project, it is not so easy for the province/prefecture to collect a subsidy from the Ministry of Interior. Considering their financial capacities, the dissemination system should be economical. Downgrading of the old master plan should be allowed as far as the originally expected effects are not lost significantly.

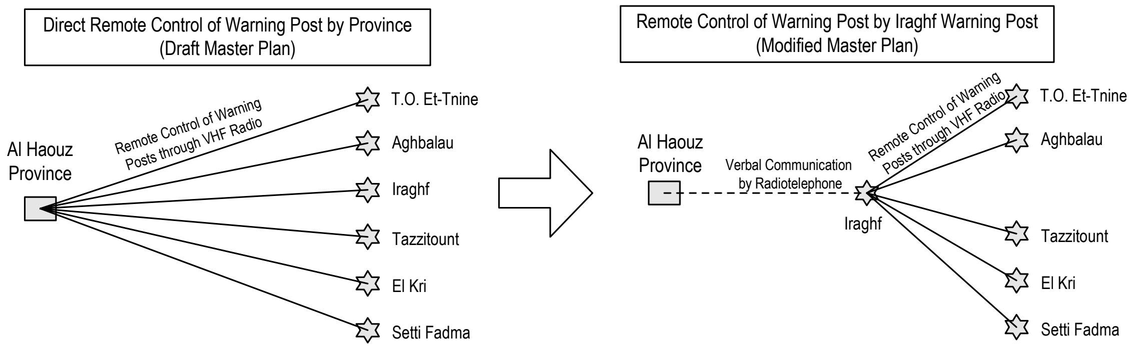
(a) Introduction of Semi-automatic System

In the draft Master Plan an on-line automatic dissemination system from the province/prefecture to the warning posts was proposed to reduce transmission time and to avoid man-made errors. The warning posts are remote-controlled by the province/prefecture without any human-interfaces in-between.

In the Pilot Project, on the other hand, a semi-automatic system that includes manual operation of warning broadcasting equipment at the warning post was examined as an intermediate step for the Mater Plan. According to the simulation drill results made in the Pilot Project, the semi-automatic system was still effective enough to disseminate warning messages from the province to the inundation area in a few minutes.

The same indirect semi-automatic system is proposed for the Master Plan except for the Ourika Valley that is the more important in terms of damage potential. 11 warning posts equipped with broadcasting equipment are created. These posts are usually unmanned and maintained voluntarily by local inhabitants, but communication with the province/prefecture is secured through a radiotelephone when necessary.

For the Ourika Valley that includes 6 warning posts located close to each other, a remote control system is proposed in a more integrated manner. The Iraghf Warning Post where a guardian is stationed 24 hours a day plays a role of a sub-control center for the other five unmanned warning posts in the valley. The five unmanned posts are connected with VHF radio to, and remote-controlled by the Iraghf Warning Post. Once a flood warning is received from the province/prefecture through the existing radiotelephone, the guardian of the warning post operates the remote-control equipment to broadcast a corresponding warning message at the other five posts and itself. The modified warning dissemination network is presented in Fig. 10.2.2.



Modification of Warning System Network for Ourika Valley

(b) Cost Reduction

With the above modification, the total equipment cost of the warning dissemination subsystem is reduced by Dh 5.4 million, from Dh 15,7 million to Dh 10.3 million.

10.2.3 Modification of Operation and Maintenance Plan

The FFWS, the man-machine system can work well only when both parts of equipment and manual operation work normally. In the Pilot Project, however, a lot of errors related to the institutional aspects were raised in the manual operation work. Most of them were very simple but fatal to the FFWS.

In order to assure the appropriate manual operation, the following things are newly proposed or reiterated again to highlight them.

(1) Creation of Coordination Committee

Flood forecasting and warning as well as subsequent rescue and relief activities involve many kinds of organizations as role players. For better operation of FFWS and subsequent activities, cooperation and coordination among relevant entities are inevitable. As prepared recently as well as recommended in the National Master Plan against Flood by DGH, establishment of a deliberative organization for flood control activities will realize the coordination among the relevant organizations necessary for FFWS and subsequent activities. The National Master Plan named such a committee "Provincial/Prefectural Committee for Flood Risk Management".

Activities of the committee should include post-flood evaluation after each flood on flood management activities as well as conducting trainings and drills. For evaluation, the committee should organize a team nominating staff among personnel in member organizations at first. The committee should compile a report, send to the Supreme Council of Water and promote implementation/operation and cooperation of relevant sector organizations to improve flood-fighting activities. The committee is also expected to lobby for the promotion of the Master Plan and to assist local inhabitants in preparation and revising of the evacuation plans.

As explained in Subsections 2.9.2 and 9.3.3, a committee for risk management, placing emphasis on combating against floods in the Ourika Valley is in preparation for the establishment with the leadership of the Governor and secretaryship of ABHT. The members of the committee will be composed of representatives of Al Haouz Province, Civil Protection, Royal Mounted Police, Auxiliary Forces, DPE, Public Health, DREF, Caidats, Comunes, etc. This committee is expected to develop into the one for the Master Plan covering all the Study Area.

(2) Strengthening of Permanence Duty

To establish a permanent duty, 24 hours a day and 365 days a year, for normal phase in ABHT, DPE, the Province/Prefecture, and Caïdat Offices is a must for the proper operation of FFWS. Especially strengthening of that of ABHT who failed in the two recent floods is of great urgency. One person at least who can receive DMN message, hear the pre-alert or alert alarms, operate the Client PC for monitoring and know what to do in case of change in phases should stay in the reach of the alarm sounds at the office, equipped with necessary communication tools and documents.

Although specific problems were not found, the lists (persons to be called, organizations to be communicated, available materials or resources) stipulated in ME Guideline and ORSEC plan are not updated, are not clearly published or are not available for all relevant persons. Preparation, publication and display are essential for smooth operation in catastrophic conditions. It would better to establish common rule and exchange the lists among relevant entities.

(3) Explanation and Training (Drills) for Full Understandings

Since the FFWS installed in the Pilot Project and planned in the master plan is new and have not yet been familiar to all of the related persons, especially those work for the Province and offices under it. For the reliable and prompt operation as well as for subsequent evacuation activities, all of the related persons have to know the contents and limits of the system, although level of required knowledge might be different depending on the role of each person in FFWS and subsequent activities.

Several members of ABHT should know in detail for full and effective utilization of the system as well as to improve the system through experiences and data accumulation and analysis. In addition, they are also expected to educate and train personnel of the other related organizations.

Current flood notice messages by ABHT provide only data on rainfall and water levels at the flood watch stations. It would better to transfer not only such data but also analytical and interpreted information to serve effective and timely subsequent activities. Substantial know-how on meteorology, hydrology and hydraulics may be required. Besides knowledge accumulation, much effort will be necessary for upgrading skills of core staff of ABHT.

(4) Interactive Analysis with DMN and ABHT

Taking high risks of debris flows and flash floods in the area, weather forecasting on rainfalls is a crucial factor for timely operation of the system as revealed in the Pilot Project. Ideally, radar installation for the region and rainfall forecasting based on analysis of the data from the radar can serve for reliable and timely forecasting of floods and debris flows. Even at present, full utilization of the capacity of DMN Marrakech Station may help ABHT very much, although currently it has limited observation stations and other resources. Close contact with DPE and Province and information collection also may help.

(5) Importance of Information from Local Authorities

Since the FFWS has limits, supplemental information collection and its analysis are essential for more effective operation of flood-fighting. Besides the interactive analysis with DMN, information from local people is also every important. As traditionally done, local people report to each Macadam when some unusual occasions arise. Then the Macadam sends the reports to the Macherikha, and the Macherikha to the Caïdat, the Caïdat to the Cercle, and the Cercle to the Province, following well-established hierarchy. Recent rapid diffusion of the mobile phones and expansion of their covering areas are also making these procedures easier and faster. Although accurate quantitative data are not expected, news given the local authorities is supplementary to limited quantitative data from the flodd watch stations. The province/prefecture as well as ABHT, should analyze the local information during preparatory and flood watch phases.

(6) Evaluation and Grade-up Applying Management Cycle

Post-evaluation on actual floods damages as well as on activities to reduce the damages is very useful to improve future activities. Many lessons can be learned, or most of sources for the improvement of the activities can be derived from the evaluation. Evaluation should accompany a report, covering the followings.

- Records of damages (type, locations, scales) and major cause of each type of damages;
- Records of communications and activities for evacuation and rescue, and review and assessment of the activities;
- Measures to be taken to improve forecasting, issuance and transmission of flod notices;
- Measures to be taken to improve issuance and dissemination of flood warnings and;
- Measures to be taken to improve evacuation and to further reduce the damages.

(7) Participation of Inhabitants and Tourism related Industries

As proved in the simulation drills, inhabitants, especially of managers and employees of restaurants, hotels or shops are willing to participate in evacuation. Participation of them will help effective evacuation. Instead of the current participation of volunteer base, it would better to organize their participation into an evacuation organization as explained in Subsection 5.3.5 under the leadership of Caidats, Communes, Douors and through discussions within associations of tourism related industries.

As requested by some restaurants and hotels during the drills, it would contribute to effective evacuations to display signboards to show evacuation routes and sites in restaurants and hotels permanently.

10.2.4 Comprehensive Approach for Disaster Prevention

As reiterated in the previous chapters and revealed in the recent floods, it is impossible to totally prevent and/or mitigate rain-induced disasters in the Atlas Region such as floods from main rivers and tributaries, debris flows and slope failures with the FFWS alone. Comprehensive approach composed of combinations of a variety of structural and nonstructural measures is essential against the disasters. It is declared that the FFWS Master Plan should be positioned among the multiple measures. Details of this comprehensive approach are described in the following chapter.

10.3 General Description of Master Plan

The draft Master Plan of Subsection 5.5 is rewritten with the slight modifications as below:

10.3.1 Objective of Proposed FFWS

The proposed FFWS Master Plan (hereinafter referred to as the Atlas Region FFWS Plan) aims to protect inhabitants and tourists in the following high risk areas (refer to Fig. 5.3.1) from river flood and/or debris flow disasters by evacuating them appropriately in time:

High Risk Areas

River Basin	Prefecture/ Province	High Risk Area	
		Area	Type of Disaster
R'dat	Al Haouz	Tazlida Tributary	Debris flow
Zat	Al Haouz	Tiferent Douar	Debris flow
Ourika	Al Haouz	Tiguemmi-n-Oumzil et Tnite and the long stretch from Aghbalau to Setti Fadma	River Flood and Debris flow
Rheray a	Al Haouz	R'ha Mouley Brahim and Asni Market	River Flood
		Imlil	Debris Flow
N'fis	Al Haouz	T. N. Yakoub	River Flood
		Imigdal Tributary (Tisgui and Targa Douars)	Debris Flow
Issyl	Sidi Youssef Ben Ali	Municipality of Sidi Youssef Ben Ali and Guannoune Douar	River Flood

High risk areas other than those along the Issyl River that flows down Sidi Youssef Ben Ali Prefecture are all located in Al Haouz Province. At least a warning post is installed at every high risk area to warn inhabitants and/or tourists of a risk of a river flood and/or debris flow disaster.

10.3.2 Institutional Plan

(1) Responsibility Allocation and Coordination

Basic demarcation in FFWS – ABHT; flood notices and the communication to the Province/ Prefecture and the Province/Prefecture; issuance and dissemination of flood warnings – is clear as confirmed during the implementation of the Pilot Project. Ownership of the equipment for FFWS and responsibilities of its operation should correspond to the demarcation.

Involvement of Principal Organizations in Atlas Region FFWS

Subsystem	ABHT		Province/Prefecture	
	ABHT in Marrakech	Flood Watch Stations	Head Quarter	Warning Posts (Evacuation Org.)
Hydrological Observation and Data Collection	R, S, I	R, I	A, S	A, I
Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices	R, I			
Issuance of Flood Warnings	A		R, I	A
Dissemination of Flood Warnings			R, S, I	R, I
Execution of Evacuation			R, S	R, I

As for operation and maintenance of equipment of FFWS, the demarcation of the above should apply. The ownership of the equipment belongs to the ABHT and the Province according to the scope of the operation. Having the basic recognition of the demarcation, the Province can make agreement with ABHT or DGH for technical or financial supports to realize consistent maintenance throughout the system. Routine maintenance, however, should be carried out by respective organizations.

Flood-fighting activities should involve various sector organizations. Civil Protection is in charge of management and coordination of rescue and relief activities against all types of disasters including those by floods and debris flows. The security organizations such as Royal Mounted Police and Auxiliary Forces, should keep public order even in cases of disasters. DPEs/DRE should be involved in flood-fighting, mainly through water and road services, including structural measures, and should assist ABHT to supplement insufficient extension capability of ABHT. Involvement of DMN is essential through weather forecasting and provision of climatological information. Urban agencies should control land use in areas prone to floods and debris flows for residential, social, commercial and industrial establishments, while agricultural sector, mainly thorough Water and Forest to prevent slope failure outside the public hydraulic domain. Countless other involvements of many sectors, such as tourism or health sector, are inevitable for effective activities.

It would be necessary to describe the responsibility and duties on flood risk explicitly in job description of each relevant sector organization and assign specific personnel.

Cooperation and coordination is essential for reliable and timely operation of FFWS and effective activities to reduced the damages caused by floods and debris flows. Provincial/Prefectural Committees on Flood Risk Management, as currently prepared in Al Haouz Province, is required for deliberative functions, while implementation of relevant entities that will compose of the committees. The committee would preferably be established separately from and under the Provincial/Prefectural Commissions Water, focusing flood-fighting activities, because of different composition from the commission. In addition to the membership prepared at present, a member from DMN Marrakech Station is required as learned during the pilot project. It is also recommendable to add a representative from radio or TV broadcasting organizations to start their involvement in flood forecasting and warning.

The Committee should meet periodically and when necessary, preferably as follows:

- Once at the time to prepare budget for the next fiscal year to confirm or discuss implementation plans of relevant organizations for flood-fighting;

- Once in May or June to confirm and exchange of lists for communication or others and to prepare a drill for June or July;
- Once in June or July to review performance of the drills and to confirm or revise rules for communication and joint operation for flood forecasting and warning; and
- Once soon after every flood to organize evaluation team composed of the member organizations and once in one or two months later to compile and issue a report for evaluation of flood damages and flood-fighting activities and reviewing of implementation plans of the Master Plan.

(2) Organization Setup

Establishment of a specific section (service) in charge of flood-fighting in ABHT is recommendable, in addition to the establishment of the committees. A few engineers and a few technicians would be required. The section will be in charge of all matters of ABHT related to FFWS and other flood control activities. The section is also in charge of explanation and training of relevant persons on FFWS. The section should be a core of researches on flood control or fighting, especially flash floods and debris flows with supports of a central administration, DGH or a national observatory as recommended in the study for National Plan of Protection against Floods.

Implementation of permanent duties is crucial. Core organizations like ABHT (Master Information Center) and its Flood Watch Stations, and the Province (or Prefecture) and the Caïdat (Monitoring Stations) and DPEs should establish shifts according to the development of the Master Plan. The core organizations should also organize FFWS operation teams when necessary and prepare the shifts as mentioned in the draft Master Plan. In addition, a preparatory team should be established in the Province and the Caïdat Monitoring Stations, as learned during the pilot project.

Organization set-up for the Warning Post and Flood Watch Stations has been conducted successfully in general during the pilot project. ABHT and the Province can continue the efforts for staffing the posts and stations in the same way according to the implementation of the Master Plan.

Participation to evacuation by tourism related entities has also been started successfully. To enhance their capability for guiding evacuation of tourists, further efforts to organize the managers and employees of restaurants, hotels and shops as teams for flood-fighting activities. Discussions with the associations of tourism related entities are necessary.

(3) Strengthening and Systemization of Voluntary Disaster Prevention Activities

There are innumerable potential disaster areas in the Study Area, while the proposed Atlas Region FFWS Plan targets the high risk areas only. The low risk areas where damage potentials are estimated relatively lower than the high risk areas are actually still exposed to dreadful disasters. Even the high risk areas to be covered by the FFWS Plan will be not perfectly safe due to technical limitation of the forecasting methods for a river flood and a debris flow such as devastated mountainous areas. It might be risky for inhabitants to depend on the new FFWS alone so much. An universal principle of disaster prevention, "*Our lives must be protected by ourselves*" will be still essential even after the completion of the Atlas Region FFWS Plan.

In this context, inhabitants' voluntary disaster prevention activities that are currently based on their experiences and goodwill should be strengthened and systemized in both the high and low risk areas. The following voluntary activities will supplement the Atlas Region FFWS Plan that will be never able to eliminate all disaster damages in the Study Area:

- Establishment of an evacuation organization even in a low risk area,
- Handing down experiences from elder generations to younger generations,
- Refraining from building houses in flood and debris flow prone areas, and
- Rainfall observation.

Governmental organizations including the Province, the Prefecture, DPEs and ABHT is required to input technical supports including publicizing of hazard maps, giving advice on designation of evacuation places.

10.3.3 Components of Atlas Region FFWS Plan

The Atlas Region FFWS Plan is a total system composed of five subsystems extending from hydrological observation and data collection to evacuation:

(1) Hydrological Observation and Data Collection

The Atlas Region FFWS Plan has 20 flood watch stations. 12 stations have both a rainfall gauge and a water level gauge, and the remaining 8 stations are rainfall stations.

All the flood watch stations are equipped with an automatic telemeter system that enables automatic measurement of rainfall and water level and real-time data transmission to ABHT. Usually the measurement and data transmission is made every an hour. Once rainfall of more than 1 mm is detected at any station, the interval of the measurement and transmission is changed into 10 minutes not to miss a sudden growth of the rainfall.

Following the Pilot Project, a radio telemetry system of 70 MHz band VHF is proposed as shown in Fig. 10.2.1. Three more frequencies are necessary in addition to the two frequencies of 70.325 and 72.325 Mhz of the Pilot Project.

An observer that is recruited from a neighboring douar is assigned to each of the 18 stations except the Oukaimedan and El Azib-n-Tinzar stations that are located very far from populated areas. He lives with his family in the residence built next to the station and takes care of the measurement and radio equipment. When the equipment does not work properly, he is to measure rainfall and/or water level and transmit them to ABHT manually under the guidance of ABHT. A list of the flood watch stations is given in Table 5.3.1 and their locations are presented in Fig 5.3.1.

(2) Data Analysis, Forecasting, Announcement of Flood Notices and Distribution of Flood Information/Notices

The collected hydrological data are processed and analyzed in ABHT which plays a role of a master information center of the FFWS in the Study Area. Forecasting of a river flood and a debris flow is also made by ABHT. Based on the analysis and forecasting, ABHT is to announce Flood Notices that are defined in the Subsection 5.3.2. The Flood Notices and processed flood information are distributed to related organizations through the Internet, public telephone, fax, and/or VHF radiotelephone. Fig. 5.5.1 presents communication networks among related organizations involved in the FFWS, and Fig. 5.4.3 gives a schematic diagram of the computer network among ABHT (the Master Information Center) and its monitoring stations.

Recipients of Flood Notice

Classification	Recipient
Local Authorities	Relevant Province/Prefecture
Other Related Organizations	DGH, Relevant DPE, ONEP, ONE, ORMVAH,DMN

(3) Issuance of Flood Warnings

The governor of the province/prefecture is to issue Flood Warnings that directly call for caution and evacuation of inhabitants and tourists in the high risk areas, based on the Flood Notices announced by ABHT and other information. Definitions of the Flood Warnings are given in Subsection 5.3.3.

(4) Dissemination of Flood Warnings

The Flood Warnings are disseminated from the Province/Prefecture to warning posts and related organizations as shown in Fig. 5.5.1.

Recipients of Flood Warning

Classification	Communication Measure	Recipients
Warning Post	Warning Broadcasting System	Inhabitants and tourists
Local Authorities	Telephone, Fax, VHF Radiotelephone	Relevant Cercles, Caidats
Other Related Government Organization	Telephone, Fax	Royal Mounted Police, Civil Protection, Ministry of Interior, and other organizations involved in ORSEC Plan
Broadcasting Mass Media	Telephone, Fax	Mass Media (TV and Radio)
Tourism Related Industries (hotels, restaurants, etc.)	Telephone, Fax	Managers and Employees, then Tourists

The Atlas Region FFWS Plan has a total of 17 warning posts as shown in Fig. 5.3.3. These posts are provided with warning broadcasting equipment. Live or recorded warning messages are directly broadcast under the remote control of the Province/Prefecture.

Ordinary telecommunication measures such as public telephone and fax are used for the warning dissemination to the related organizations that are located far away from the possible disaster areas. For the lower local authorities such as cercles and caidats, the VHF radiotelephone network of the Province/Prefecture can be used.

The 11 warning posts except those in the Ourika Valley are equipped with a radiotelephone too for communication with the province/prefecture. The posts that are to be maintained by the evacuation organization of inhabitants are unmanned at normal times, but when a person in charge is stationed when necessary. As for the Ourika Valley, the Iraghf Warning Post where a guardian is permanently stationed plays a role as a control center of the other five posts. The unmanned five posts are remote-controlled by the Iragh Warning Post that receives necessary directions from the Province through the radiotelephone. Fig. 10.2.2 gives a schematic diagram of the warning dissemination network.

(5) Evacuation

Evacuation must be made appropriately and promptly in accordance with an evacuation plan that is to be prepared for every high risk area under the initiatives of the Caidat, Cercle, and

Douar. The evacuation plan must contain the following contents as discussed in Subsection 5.3.5:

- Evacuation Organization;
- Operation and Maintenance of Warning Post;
- Evacuation Places and Routes;
- Stock of Materials and Equipment;
- Diffusion of Warning Messages;
- Guidance of Evacuees;
- Guidance of Tourists;
- Evacuation Drill;
- Public Relations; and
- Evaluation of Evacuation Activities and Updating of Evacuation Plan.

10.3.4 Proposed Operation and Maintenance Plan

An operation and maintenance plan for the principal organizations is elaborated as follows:

(1) Flood Phase

To make clear actions and procedures to be taken in response to different stages of a flood, a flood period is divided into four Flood Phases, namely Normal Phase, Preparatory Phase, Flood Watch Phase and Evacuation Phase in an order of seriousness of the flood situation. The principal organizations, ABHT, DPE Al Haouz, DPE Marrakech, Al Haouz Province, Sidi Youssef Ben Ali Prefecture and the warning posts are required to take appropriate actions in accordance with operation procedures stipulated for each of the Flood Phases in the operation manual.

The DMN Pre-alert and Alert Messages and the ABHT Flood Notices are used for transition from one phase to another as explained below:

(a) Normal Phase

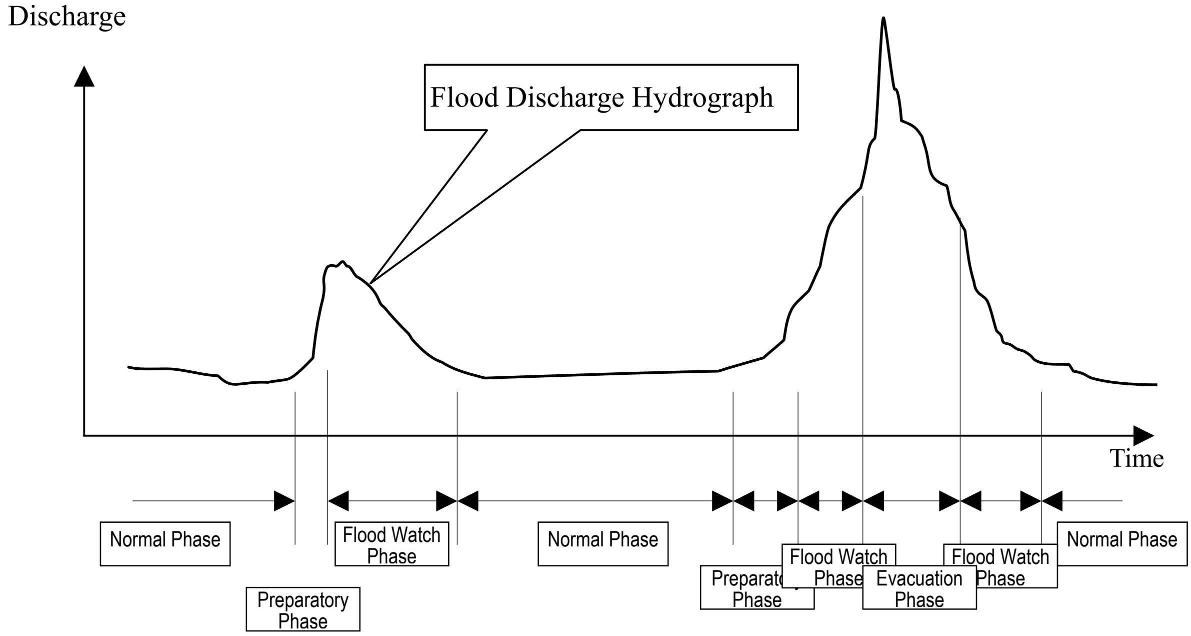
The Normal Phase is a pre-flood period or a post-flood period when the danger of a river flood and/or debris flows is not predicted at all.

Once a Pre-alert Message or an Alert Message has been announced by DMN during this phase for Al Haouz Province and/or Sidi Youssef Ben Ali Prefecture, the Preparatory Phase commences. Once a Pre-River Flood Notice and/or a Pre-Debris Flow Notice has been announced by ABHT for any warning post area during the Normal Phase, the Flood Watch Phase breaks directly.

(b) Preparatory Phase

The Preparatory Phase is usually a period when it is about to rain soon or it has already started to rain slightly.

Once a Pre-River Flood Notice and/or a Pre-Debris Flow Notice have been announced by ABHT for any warning post area, the Preparatory Phase terminates and the Flood Watch Phase commences. If the flood situation is not worsened, the Preparatory Phase terminates with termination of the DMN messages and the Normal Phase resumes.



Transition of Flood Phase

(c) Flood Watch Phase

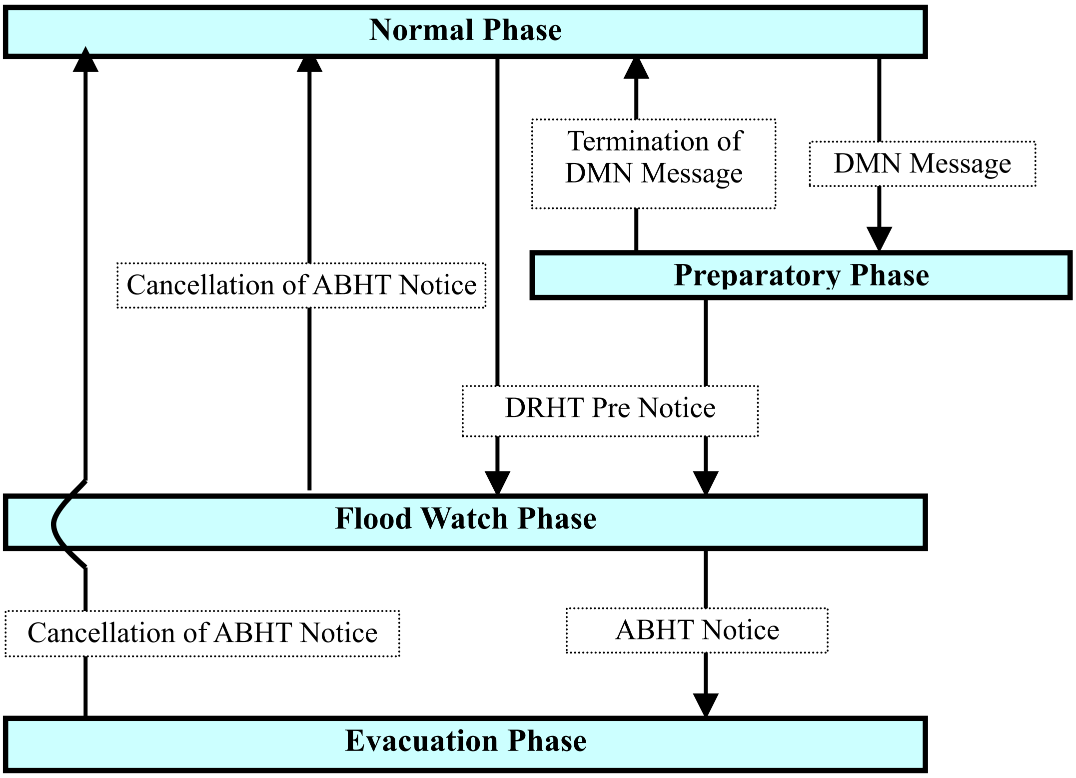
The Flood Watch Phase is a period when the flood situation has been worsened so badly that some symptoms of a flood and/or debris flows such as heavy rainfall and swelling of river water have appeared actually.

Once a River Flood Notice and/or a Debris Flow Notice have been announced by ABHT for any warning post area, the Flood Watch Phase terminated and the Evacuation Phase commences. Once the flood situation has settled enough for ABHT to cancel all the Pre-River Flood Notices and Pre-Debris Flow Notices, the Flood watch Phase terminates and the Normal Phase resumes.

(d) Evacuation Phase

The Evacuation Phase is a period when the flood situation has been worsened so badly that evacuation is necessary.

Once the flood situation has settled enough for ABHT to cancel all the River Flood Notices and the Debris Flow Notices, the Evacuation Phase terminates and the Flood Watch Phase resumes.



Transition of Flood Phase and Flood Notices

(2) Actions and Procedures to be Taken by Principal Organizations

Concrete actions and procedures that should be taken during each of the four Flood Phases by the principal organizations including their field stations and posts are listed in the operation manual, and summarized as follows:

(a) FFWS Operation during Normal Phase

In this phase no immediate actions are generally needed. In order immediately to respond to any subtle symptom of a storm including DMN messages at any time, however, the principal organizations must keep on duty 24 hours even in the Normal Phase. Moreover, the FFWS equipment shall be maintained in good condition.

The principal organizations, ABHT, DPEs, the Province and the Prefecture shall gather to have a meeting for updating of this operation manual, and to discuss on a joint communication drill in May or June, gathering representatives from their field offices and related organizations. The joint drill involving all the principal organizations shall be made in June, just before the tourist season. Before the joint drill, every organization must conduct an internal FFWS operation drill once a year at least to remind all the personnel concerned of the FFWS operation procedures. After every flood that reached the Preparatory Phase or further and every joint drill, all the principal organizations should meet after compiling each evaluation report on its FFWS operation, which is to be referred to for updating of the operation manual.

(b) FFWS Operation during Preparatory Phase

The most important thing during this phase is to get ready against a growing rainstorm. A FFWS operation team consisting of an engineer (or an officers) and some technicians shall be organized as soon as this Preparatory Phase commences, so as to respond to sudden development of the rainstorm.

The observers of the flood watch stations, the technicians of the DPE brigade posts and the caretakers of the warning posts also must stand by under the guidance of ABHT, the DPE Headquarters and the Province/Prefecture respectively.

(c) FFWS Operation during Flood Watch Phase

The Flood Watch Phase is a period when the flood situation has been worsened so badly that some symptoms of a flood and/or debris flows such as heavy rainfall and swelling of river water have appeared actually. Keeping watch on the flood situation is the most important task for all the principal organizations during this phase.

The flood situation often jumps to the Flood Watch Phase directly from the Normal Phase if a DMN message is not announced during the Normal Phase. If so, a FFWS operation team must be established immediately.

(d) FFWS Operation during Evacuation Phase

The Evacuation Phase is an emergent period when the flood situation has been worsened so badly that immediate evacuation of inhabitants and tourists is necessary at some warning posts. Prompt issuance and dissemination of Evacuation Direction is the most important during this phase.

10.3.5 Human Resource Development Plan

At first, ABHT or staff of the section in ABHT assigned to flood-fighting activities should understand in detail the FFWS installed by the pilot project as well as that proposed in the Master Plan. The section then has to explain the contents and limits of the system to all relevant entities. Training by the section is also necessary for all operating persons, including those nominated in the FFWS operation teams and preparatory teams as well as tourism related persons who guide evacuation of tourists. In-situ explanations and training would be more effective. Corresponding to development of the system and changes of personnel in charge in relevant organizations, the explanation and training should be conducted continuously.

The section of ABHT should substantially grade-up its own technical level to improve the FFWS. To provide useful and effective information, rather than just data observed, much efforts should be made to strengthen analytical capabilities. To cope with debris flow and flash floods, analyses on hydrological data and information should largely be enhanced. Assistance of DGH will be required. Due to the expected leading position in Morocco, domestic source of information might be insufficient and utilization of cooperation programs by foreign countries or international organizations, such as World Meteorological Organization (WMO) can be recommended.

10.4 Implementation Plan and Cost Estimate

10.4.1 Implementation Plan

As explained in Subsection 10.2.1, two implementation plans, namely 5-year and 10-year implementation plans were proposed. The two plans are illustrated in Table 10.4.1.

In the Alternative-1: 5-year Implementation, the Master Plan is implemented at once in 5 years between 2005 and 2009. In the Alternative-2: 10-year implementation, it is implemented in three phases between 2005 and 2014 according to the priority order in terms of damage potential. The first priority should be given to the Ourika River Basin, the second to the issyl and Rheraya River Basins, and the third to the rests. The proposed 20 flood watch stations, 5 repeater stations and 17 warning posts including those of the Pilot Project are divided into three groups.

Grouping of Stations and Posts

Phase	Implementation Period	River Basin	Number of New Stations/Posts		
			Flood Watch Station	Repeater Station	Warning Post
1	2005 to 2008	Ourika	6 (11)	1(3)	5 (6)
2	2009 to 20011	Issyl	2	0	3
		Rheraya	2	1	3
		Sub-total	4	1	6
3	2012 to 2014	R'datt	1	0	1
		Zat			1
		N'fis	4	1	3
		Sub-total	5	1	5
		Total	15 (20)	3 (5)	16 (17)

Number in parentheses is the number of the total number of stations/posts including those of the Pilot Project.

10.4.2 Cost Estimate

The project cost and the maintenance cost for the whole Atlas Region FFWS Plan including the pilot project is approximated as follows:

(1) Conditions for Cost Estimate

(a) Price Level

The price level is as of August 1, 2003. The currency conversion rates among US Dallar (USD), Moroccan Dirham (Dh) and Japanese Yen (JPY) are: USD 1.00 = Dh 9.8638 = JPY 120.590.

(b) Constitution of Project Cost

The project cost is composed of construction cost, engineering services cost, physical contingency. Since facilities to be built such as antenna poles and houses for storage of equipment are all very small in size and located in remote mountainous areas, compensation cost including land acquisition cost and house relocation cost can be neglected compared with the other costs.

The construction cost can be further divided into equipment cost (refer to Tables 10.4.2 and 10.4.3), installation and commissioning cost, civil construction cost, software development cost and technical training cost. The physical contingency is estimated at 10% of the construction cost and the engineering services cost.

(c) Annual Maintenance Cost

Annual operation and maintenance cost is generally estimated at about 5% of equipment cost in Japan. The same rate is assumed in this Study, too.

(2) Project Cost and Conditions for Cost Estimate

Based on the above, the project cost and the maintenance cost are estimated as below:

Project Cost and Maintenance Cost for Atlas Region FFWS Plan

(Dh'000)

Cost Item	Pilot Project	After Pilot Project				Total
		Ourika	Issyl + Rheraya	Others	Subtotal	
A. Construction Cost	**16,612**	**17,229**	**9,656**	**10,213**	**37,097**	**53,710**
(1)Equipment Cost	12,826	13,497	7,498	7,929	28,924	41,750
(2)Installation and Commissioning Cost	2,072	1,552	947	1,003	3,503	5,574
(3)Civil Construction Work Cost	1,178	1,497	832	879	3,208	4,386
(4)Software Development Cost	269	341	190	200	731	1,000
(5)Technical Training Cost	269	341	190	200	731	1,000
B. Engineering Services Cost	**4,029**	**4,186**	**2,326**	**2,459**	**8,971**	**13,000**
C. Physical Contingency (10% of (A+B))	**2,064**	**2,141**	**1,198**	**1,267**	**4,607**	**6,671**
D. Project Cost (A+B+C)	**22,706**	**23,556**	**13,179**	**13,939**	**50,675**	**73,381**
E. Annual Maintenance Cost	**641**	**675**	**375**	**396**	**1446**	**2,087**

10.5 Project Evaluation

The modified Master Plan is evaluated comprehensively in this Chapter. In conclusion, the FFWS Plan is generally viable in terms of economical effectiveness, social and technical acceptability, and environmental impacts. If sufficient assistances of national and regional levels are available, the Master Plan could be viable financially too.

10.5.1 Economic Evaluation and Financial Considerations

(1) Economic Evaluation

In the same way as the draft Master Plan, economic analyses were made as presented in Tables 10.5.1, 10.5.2, 10.5.3, 10.5.4, 10.5.5 and 10.5.6.

For the economic evaluation, Economic Internal Rate of Return (EIRR), Benefit-cost ratio (B/C) and Net Present Value (NPV) were recalculated for the modified Master Plan. The results are shown in the following table.

EIRR, B/C and NPV

Item	Alternative-1 (5-year Implementaton)		Alternative-2 (10-year Implementation)	
	Movable Assets only	Human Life included	Movable Assets only	Human Life included
EIRR	Negative*	16.7%	Negative*	19.7%
B/C	0.08	1.6	0.08	1.7
NPV	-Dh 50 million	Dh 31 million	-Dh 45 million	Dh 31 million

As noticed from the table, the project can be nearly feasible, if the value of a human life is appreciated in the monetary term. Although it is very difficult to evaluate the human life in the monetary term properly, it is considered to include a human life to evaluate the project from the economic aspect, and, under such a condition, it is expected that the project will be feasible from the economic aspect.

As for the comparison of the two alternatives, EIRR of the longer-term implementation is slightly bigger that the other. Considering many assumptions applied for the analyses, however, this small difference seems meaningless. The implementation period would rather be determined in consideration of the financial conditions.

(2) Financial Considerations

Annual additional burdens for the maintenance of equipment are Dh 1,502,000 on ABHT, Dh 540,000 on Al Haouz Province and Dh 45,000 on SYBA Prefecture if the total maintenance cost of Dh 2,087,000 is divided according to the cost of the equipment installed in their jurisdictions.

These burdens are still small for all the three organizations, though those for Al Haouz Province and SYBA Prefecture were considerably reduced from the draft Master Plan. Involvement and assistance of regional and even national levels is a must, similar to the Pilot Project, of which maintenance cost is shouldered by DGH. The proposed coordination committee is expected to become a propeller for promoting the Master Plan.

O&M Responsibility and Cost Burden on Administrations

(Dh'000)

O&M responsibility		Draft Master Plan		Modified Master Plan	
		Equipment cost	O&M cost	Equipment cost	O&M cost
ABHT (formerly DRHT) - The data processing sub-system except 5 monitoring stations - The data collection sub-system		30,039	1,502	30,039	1,502
Al Haouz Province	- A part of the data processing sub-system (5 monitoring stations) - Warning dissemination sub-system except 3 warning posts	14,447	722	10,807	540
SYBA Prefecture	- A part of the warning dissemination sub-system (3 warning posts)	3,262	163	905	45
Total		47748	2,387	41,750	2,087

10.5.2 Consideration of Social Aspect

Main concern about social aspects is acceptance of the Master Plan by local inhabitants and tourists in the Study Area who are supposed to be the beneficiaries.

For inhabitants, their strong concern was proved in the Pilot Project. About 30 % of the inhabitants voluntarily participated in the evacuation drill on 25 June 2002 held at Iraghf of the Ourika Valley. This high rate is a proof of high interests of the inhabitants, and the interests probably came from the memories of the catastrophe in 1995. Since such shocking experience caused by natural disasters is shared among the other high risk areas, it is natural to think that inhabitants of the other high risk areas also understand necessity of preventive measures. In this sense the local inhabitants have an aptitude to accept the Master Plan, though assistances and initiatives of local authorities is necessary for them to develop themselves to create evacuation organizations.

According to an interview to tourists in the Ourika Valley made in 2000, 92 % of the interviewees answered that they knew the 1995 catastrophe. The high rate is welcomed and is to be maintained or improved more. In the evacuation drills in 2002 and 2003, however, the participation from tourists was very limited, probably because they did not wanted to be disturbed. Efforts to publicize the past disasters and the FFWS shall be made continuously, not discouraged by the failures in the drills.

10.5.3 Initial Environmental Evaluation

As described in Subsection 5.8.3, the Initial Environment Evaluation(IEE) on the draft Master Plan concluded that it was considered not necessary to make an environmental impact assessment study because no serious impacts was predicted due to the small scale of the Master Plan project. The fact that no adverse impacts of the Pilot Project have been reported is also supporting this IEE. The same conclusion can be given to this modified Master Plan that is too slightly different from the old one.

10.5.4 Technical Acceptability

The Pilot Project was a good opportunity for technical transfer. In this project period of about two years between 2001 and 2003, a variety of training programs and simulation drills were held for personnel concerned. The experimental operation was a runway for them to take off by themselves.

Especially ABHT technicians who joined the installation works learnt a lot about the high-tech equipment from the Japanese engineers. Although it is still difficult even for them to repair the equipment, they became capable of the operation of the pilot system at least. It can be said that ABHT is almost ready to accept the Master Plan.

On the other hand, insufficient understandings of personnel of the Province, Ourika Caidat and the Iraghf Warning Post were also disclosed in the Pilot Project. Most of the personnel concerned of the local authorities who are not originally technical stuff need to be further more educated and trained. Thus ABHT is to train the personnel in the Master Plan. To promote such inter-organization cooperation will be one of the roles of the provincial/prefectural coordination committee.

CHAPTER 11. COMPREHENSIVE APPROACH TO DISASTERS IN ATLAS REGION

11.1 General

In the Atlas Region all kinds of rain-induced disasters are possible. They are river floods, debris flows, land slides, slope failures, falling rocks, as repeated so often in the past. This Report describes the Master Plan of FFWS against the disasters in the region. However, the FFWS has its own limitations in terms of effectiveness. The FFWS is originally not a measure to eliminate all the damage completely but only a supporting measure to forewarn the people about the disaster risks. The safety of the people could not be assured unless they themselves take appropriate actions, for example evacuate promptly to safe places, to avoid the risks based on the warnings given by the FFWS. Depending on the magnitude and characteristics of the disaster, however, they can fail even if they do their best. Furthermore, damage to immovable assets such as infrastructures, buildings and agricultural products is unavoidable with the FFWS alone.

To substantially mitigate the disaster risks in the region, multiple approach is indispensable. Combinations of several structural and nonstructural measures should be provided in addition to the FFWS. Some conceivable structural and non-structural measures are introduced briefly, as below:

11.2 Introduction of Structural Measures

As a basic infrastructure for disaster prevention structural measures should be provided on a certain level. Non-structural measures are generally employed to compensate for what the structural measures can not cover.

In this Study, conceptual plans of structural measures have been made by examining the applicability of structural measures in the Study Area, as presented in the following subsections (refer to Volume 3, Supporting Report Appendix H: Structural Measures for details).

11.2.1 Current Provision of Structural Measures against Flood Damage

To cope with the habitual flood damage, agencies concerned had provided several structural measures such as check dams, river channel widening and deepening, construction of embankment in the Ourika and Issyl river basins, as discussed before. However, these measures are still far from a satisfactory level in both quality and quantity (refer to Subsection 2.8.2). In the case of other basins, few structural measures have been provided.

11.2.2 Applicable Structural Measures

The applicable structural measures in the Study Area are mainly composed of those for debris flow control, erosion control and river flood flow, control, and summarized as follows:

Structural Measures

Classification	Measures	Areas
Debris Flow Control	• Large check dam • Small check dam • Channel works • Sand pocket works	Upstream, mountain basin, potential debris flow disaster stream
Erosion Control	• Small sil • Hillside works • Reforestation works	Whole basin especially upstream
River Flood Flow Control	• River channel improvement including widening, excavation of river bed and embankment • Dam and reservoir	Up, middle and lower stream

11.2.3 Consideration on the Introduction of Structural Measures

The introduction of structural measures may need a huge cost and a long time. To effectively introduce structural measures from the economical and technical viewpoints, the following considerations should be made.

(1) Detailed Investigation on Disaster Conditions

Since the currently available data and information are not enough for the application of structural measures, it is necessary to compile basic data on topography, geography, hydrology and socio-economy. It is also necessary to conduct a detailed investigation on disaster conditions just after the occurrence of a disaster for the basic analysis, planning and design of flood/debris control works.

(2) Preparation of Framework to introduce Structural Measures

In the context of long-term national development plan and the disaster prevention plan, it is necessary to prepare a framework for the introduction of structural measures, such as project scale expressed in return period of target flood and target year for realization of the projects.

(3) Formulation of Master Plan

In accordance with the framework, the Master Plan for introduction of structural measures should be formulated considering technical, financial, economic and environmental points of view.

(4) Multipurpose Utilization of Structural Measures

In principle, these structural measures are introduced for disaster mitigation. However, some of these measures can functions for other purposes such as conservation of groundwater and utilization of developed water resources. In this sense, it is necessary to consider such multipurpose utilization of structural measures.

11.3 Introduction of Non-structural Measures except FFWS

In addition to the above structural measures, the following non-structural measures are proposed to assure a desirable safety level in the Atlas Region:

- Publication of Flood Risk Maps;
- Monitoring of Debris Flow Potential Streams;
- Introduction of Traffic Control;
- Introduction of Land Use Control and Guidance; and
- Provision of Facilities for Tourists.

11.3.1 Publication of Hazard Maps

In general, the publication of a hazard map is broadly adopted as one of the useful non-structural flood mitigation measures. Through the publication of such a hazard map, the residents could be aware of the extent of possible disaster areas and the available evacuation routes during the disaster.

The hazard map, in principle, contains information on: (a) the probable extent and depth of flood inundation; and (b) the evacuation centers and evacuation routes. The hazard map could also be a guide for appropriate urban planning and land development.

As explained in Chapter 3, a hazard map of flood inundation, debris flows, land slides and slope failures was prepared for each of the six river basins though aerial photograph analyses. Moreover, probable inundation areas were delineated along the important river stretches based on the hydraulic simulation.

People that suffer from severe disaster damage include tourists, who may have little knowledge and information concerning risks in the area, especially, in tourist spots. When a disaster occurs, such people would easily panic resulting in a more severe damage, as witnessed in the 1995 flood. In this connection, it is necessary to publicize the hazard risk and the flood inundation map to tourists as well as the local inhabitants to avoid such panic and to encourage them make:

- Efforts to save their own lives;
- Efforts to help each other; and
- Efforts to inform administrations.

Besides the hazard maps, the followings are also effective for publicizing the disaster risks:

- Installation of signboards;
- Distribution of leaflets; and
- Broadcasting using mass-media and local radio networks.

It is also important to pay attention not to damage feelings of the inhabitants, especially those involved in tourism industry who are generally not positive to the above. Consultations and cooperation with the inhabitants and local authorities are indispensable.

11.3.2 Monitoring of Potential Debris Flow Streams

The Master Plan of the FFWS has been formulated with the catastrophic disaster in 1995 as the target flood. As noted from the recent 2003 floods, however, intensive rainfall can hit directly high risk areas in forms of flash floods and debris flows from tributaries and slope failures. In such an event, less lead time is allowed than river floods like the one in 1995. In the case of the 4 August 2003 rainstorm, a debris flow was generated within 20 minutes after the commencement of the rainfall. It seems very difficult for the FFWS to alarm the rainfall area in time against such a fast phenomenon.

To prepare against debris flows, it is necessary to evaluate in advance possibility of debris flows for every debris flow potential stream. To take actions after rainfall starts can be too late. Preparation in normal times is important. In this sense, it is recommended to monitor geographical changes in the stream after a rainfall of a certain intensity. This makes possible detection of a rise in potential of debris flows. For facilitating the monitoring, a card like a medical one, called “stream monitoring report” is proposed as Table 11.3.1.

When occurrence of debris flows is forecasted according to the stream monitoring report, measures including restriction of any activity in the area along the torrent, removal of materials causing disasters like big rocks should be taken in advance to mitigate potential damage.

ABHT, DPE and DREF should be in charge of the above monitoring according to their jurisdictions. Namely ABHT is responsible for major streams, DPE for streams above the roads and DREF for upper minor streams.

11.3.3 Introduction of Traffic Control

One disadvantage of the Study Area with regard to tourism, especially the Ourika River Basin, is the inadequate open space to accommodate vehicles used by many tourists into the area. Therefore, tourists park their cars on the road along the river course, which was another reason for the tragedy in 1995.

According to the traffic survey at Aghbalou Point in the Ourika River Basin conducted in this study on August 3 and 6, 2000, the number of vehicles coming in and going out of the basin is as shown in the following table.

Number of Vehicles Coming to Ourika

Date	Number of Vehicles observed at Aghbalou Point in the Ourika River Basin		Remarks
	Coming in	Going out	
Thursday, Aug. 3, 2000	731	685	Accumulated number for 12 hours from 08:00H to 20:00H
Sunday, Aug. 6, 2000	1,281	1,290	

As noticed from the table, more than 700 vehicles on weekdays and around 1,300 vehicles on holidays come into the Ourika Valley and most of them park on the road along the Ourika River course, mainly at Iraghf and Setti Fadma. The necessary length of road to park these vehicles in a line would be about 10 km, assuming that about 7m is required for parking one vehicle. Since this 10km distance corresponds to that between Iraghf and Setti Fadama, the whole section of the tourist site would be full of parked cars. Under this situation, it would be difficult for tourists as well as inhabitants to move the vehicles smoothly in the case of emergency. In answer to the interview questionnaire, “Where do you escape when a flood occurs in the Ourika River?”, about 25% of the tourists coming by their own cars said that they will first return to their cars when a disaster occurs.

Not only the tourist spots but also the roads along the rivers are dangerous. Most of the stretches of the roads are exposed to flash floods and debris flows from tributaries and slope failures. As the answers of the questionnaire and the experiences in the past floods proved, the tourists tend to rush to drive out of the valley to safer low flat areas once it starts to rain. It takes about 30 minutes from Iraghf and about 45 minutes from Setti Fadma to drive to the safe Al Haouz Plain. Whether they can successfully escape from the valleys under all the risks, it depends upon how it rain in these durations. In the case of the 4 August 2003 rainstorm that brought intensive rainfall to areas just upstream of Iraghf, tourists in Setti Fadma were unluckily locked to spend the night on the road cut everywhere by debris flows and slope failures, while those in Iraghf could escape. We had rather think that the tourists in Setti Fadma were so lucky that they were neither killed nor injured by falling huge rocks and debris. It might be wise to refrain from using cars during a flood for avoiding secondary disasters.

Recently, in Ourika Valley, parking on one side of the road has been introduced as one of the traffic control measures. However, it seems difficult to solve the traffic problem as well as the damages expected in floods by only this means.

In this connection, it is necessary to introduce drastic traffic control like the park and ride system as practiced in the other countries such as Japan, Switzerland and Austria.

11.3.4 Land Use Control and Guidance

Land use control and guidance is very important to prevent disorderly land development, which could leads to an increase of damage potential in hazard areas and to devastation of river basins. The Water Law (“10-95 Law”) also stipulates occupation of the public water domains, and is expected to be a legal background for execution of land use control.

Besides, as far as the Ourika Valley is concerned, the Urban Agency of Marrakech is formulating a land use plan along the Ourika Valley from Tnine Ourika to Setti Fadma. The plan will include zoning and prohibition of establishments or buildings in zones prone to floods or debris flows. At present, the agency is collecting hydrological information for the zoning from ABHT.

It is desirable to prepare similar land use plans for the other river basins. Thus, it is expected that the disaster hazard maps prepared in this Study will be utilized for the land use plan.

11.3.5 Provision of Tourism Facilities

Since the Study Area is famous as one of the major tourist spots in North Africa, a large number of tourists visit in summer, especially the Ourika Valley, to enjoy the cool and clean water. Thus, the Study Area is one of the precious resources for the tourist industry.

However, basic facilities for the tourism industry are poor in quality and quantity, facilities provided for tourists seem to be inadequate, especially in assuring safety against disasters caused by floods and debris flow. The following are the facilities that should at least be provided to assure the safety against disasters:

- Adequate space for evacuation sites;
- Easily accessible evacuation routes with street lights; and
- Warehouse where necessary equipment, goods and materials for emergency use are stored.