2.16 Hydrodynamic Modeling

2.16.1 Objectives and Approach

The objectives of the hydrodynamic modeling are to:

- Construct a MIKE 11 hydraulic model that can dynamically simulate flashfloods taking place in the Madarsoo River from Dasht village to Golestan reservoir.
- Apply the hydraulic model to produce flood maps for the 25-year, 50-year and 100-year flood events in the Madarsoo River from Dasht village to Golestan reservoir.
- Quantify the hydraulic impact (extend of flood and flood depth) of flood and debris flow in relevant tributaries along the Madarsoo River.

To meet the objectives, the following approach was employed:

- A MIKE 11 model network is defined for routing the floodwater down through the Madarsoo. This network should represent the path of the floodwater rather than the path of the river. In addition the DEM was not consistent with the available Quick Bird satellite images. Thus consistent DEM was chosen to define the river network.
- Cross-sections for the MIKE 11 model were drawn on top of the DEM using the river network and an extreme flood extend calculated with a 2D model.
- Boundary conditions for the MIKE 11 hydraulic model have been calculated with a hydrological model (MIKE SHE) using rainfall and topography as well as routing through a MIKE 11 network. Boundary conditions were produced for the 25-year, 50-year, 100-year, 2001 and 2005 floods.
- Calibration is very difficult for this model because it has to be used for extreme flood conditions where there is no water level data because the gauges are destroyed during these events. Calibration is therefore based on estimated values for the Manning’s “n” in a river channel and floodplain.
- Debris flow has been handled by using empirical formulas for the debris yield combined with assumptions about the distribution in time of the debris flow, resulting in time-series for the debris inflow, which are added as sediment point sources at the junctions with the debris carrying tributaries. The MIKE 11 model is then extended to include sediment transport, which results in the formation and erosion of debris deposits that impact the hydraulics. The impact of debris flow is quantified with this approach.
- Flood maps are generated in MIKE 11 GIS, which translates the 1D hydraulic model into 2D maps of the floods. Flood maps are delivered for the 25-year, 50-year and 100-year floods, and local flood maps in the debris prone reach of the Madarsoo River are delivered along with comparison maps to quantify the hydraulic impact of debris flow.

2.16.2 Model Construction

At this point a “functional” MIKE 11 model was used in preliminary simulations. This constitutes the deliverables as per the scope of work for the F/S stage in detail. The model is constructed with the following:

- DEM: Final Iran System’s DEM with improvements in downstream end compared to earlier “final” DEM.
- Cross-sections: Extracted from Final Iran System’s DEM.
- Madarsoo network: Digitized from Final Iran Systems DEM.
- Two different models are applied. An overall hydrodynamic (HD) model with bridges included, but no debris flow, while a local model in the debris prone reach is used for determining the impact of debris flow.

- Scenarios: 25-year, 50-year, 100-year floods defined through boundary conditions and source points.
- The local model takes the discharge from the overall model in the point corresponding to the inflow boundary of the local model and uses the same lateral and tributary inflows that are in the local model reach.
- Bridges: Implemented with elevations estimated from the Final Iran Systems DEM cross-sections
- Debris flow: Time-series prepared by using a=0.8 for all five scenarios, defined as sediment sources at 11 different locations. All the debris is taken as the coarse fraction (54 mm) at this point.
- Sediment: 0.5 mm and 54 mm fractions, Engelund-Hansen sediment transport formula.
- "Calibration": Manning n=0.2 s/m$^{1/3}$.

The following simulations are carried out:

- 25-, 50-, 100-year floods (overall HD)
- 100-year flood (local HD+ST) with and without debris included in order to isolate the impact of the debris

2.16.3 Results for Overall MIKE 11 HD Model

The results for the overall MIKE 11 HD model are presented herein:

- Animation of the 100-year flood
- Flood maps 25-, 50- and 100-year floods
- Road overtopping between 14 Metry bridge and Tangrah
- Water depth over the 14 Metry bridge deck

<u>Animation of 100-Year Flood</u>

Two animations were made from the 100-year flood:

- 742 satellite image as background
- Quick Bird image as background

Fig. 2.120 shows every second hour (10 August 22:00 to 11 August 22:00) of the animation with the LANDSAT ETM+ image background.

It is noted that the model is not designed for low flow, as it does not represent the river channel itself (this requires that the survey sections and the DEM are compatible). Therefore the animations should only be viewed for the peak flows and how the flood peak migrates through the Madarsoo valley and floodplain.

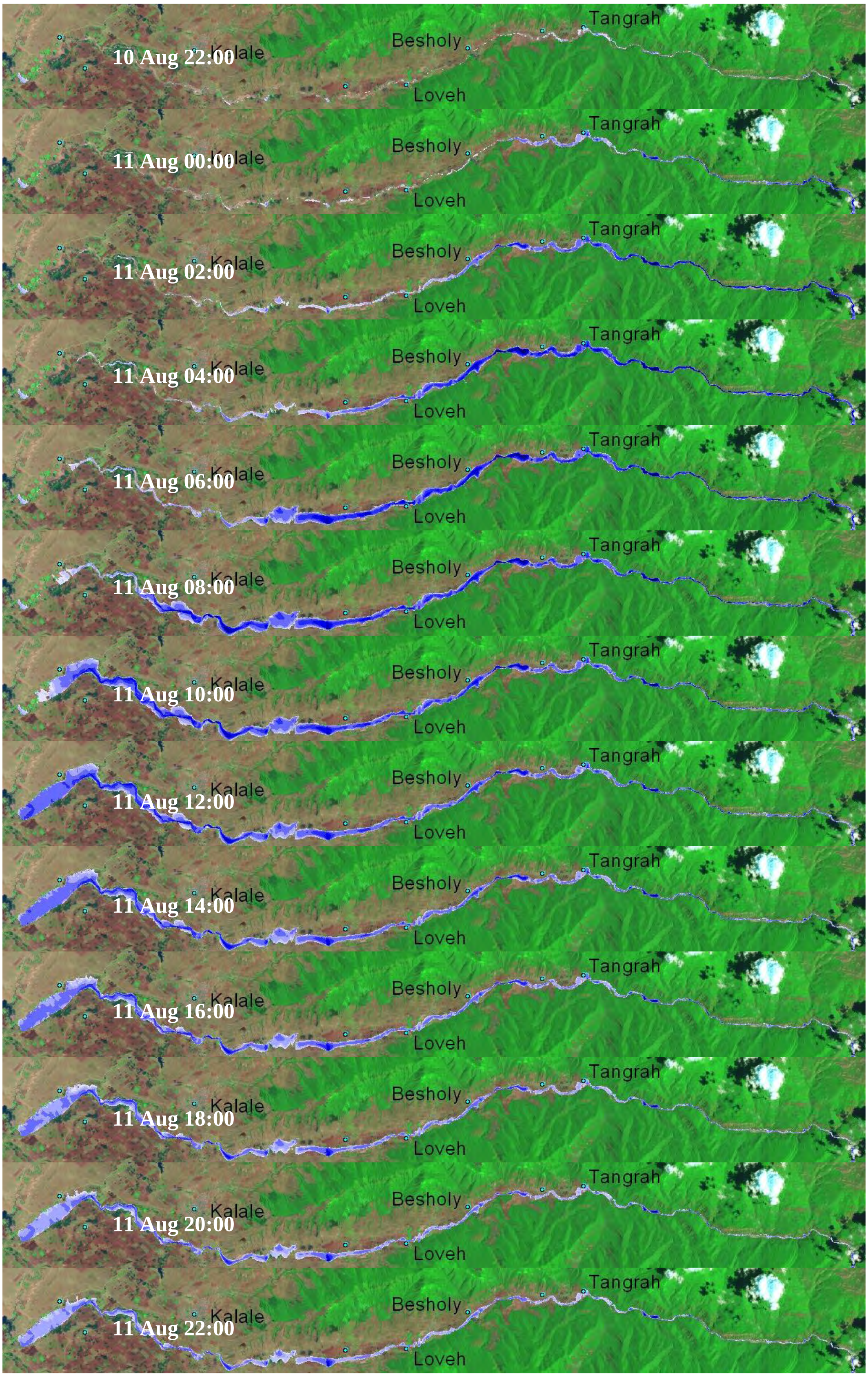

Fig. 2.120 Flood Maps (100-Year Event) from the Animation with the LANDSAT ETM+ Satellite Image

Flood Maps

Flood maps were produced for hazard map preparation. For the sake of completeness the raw (non-processed) maps that were produced with MIKE 11 GIS are shown in the following figures below.

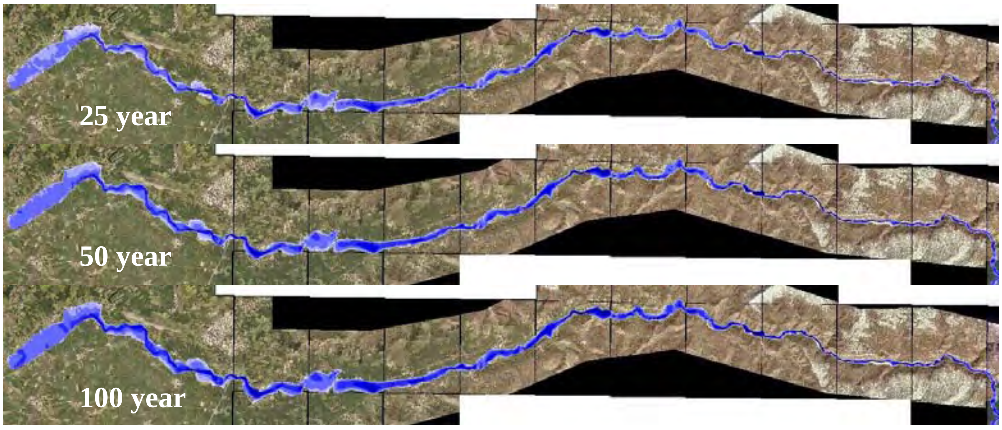

Fig. 2.121 Flood Maps Based on Simulated Maximum Floodwater Levels in 25-, 50- and 100-Year Return Periods

14 Metry Bridge

The water depth above the road over 14 Metry bridge was determined from the simulation results. The water depth over the weir was not directly available in the result file, but was determined by combining the result files with information about the weir Q-H relation.

Table 2.83 Calculation of Water Depth above 14 Metry Bridge for 25-, 50- and 100-Year Peak Discharge

Return Period (year)	Peak Flow (m^3/s)	Peak Water Level Upstream (m)	Peak Weir Water Level (m)	Water Depth Over Weir (m)	Width of River Flood Maps (m)
25	1363	235.82	235.36	0.66	650
50	1913	236.17	235.56	0.86	680
100	2527	236.53	235.78	1.08	700

The Q-H relation for the weir is used as an internal condition on the discharge over the weir as function of the upstream floodwater level. The Q-H relation in the MIKE 11 network contains this Q-H curve and also a similar curve for the Q-H relation over the weir (road). The methodology is to determine the upstream water level from the MIKE 11 results and then determine the discharge over the road (about 300 m^3/s goes through the arch), and then use the Q-H relation for the weir itself to determine the water level.

The results are shown in Table 2.83; 66 cm, 86 cm and 108 cm water depth over the 14 Metry bridge deck for 25-, 50- and 100-year peak flows.

2.16.4 Results for Local MIKE 11 HD+ST Model

Appropriate Simulation Period for MIKE 11 HD+ST Model

To clarify the situation and effects on debris avalanche save time, the debris flow simulations were only carried out with a local model and only for the 100-year event.

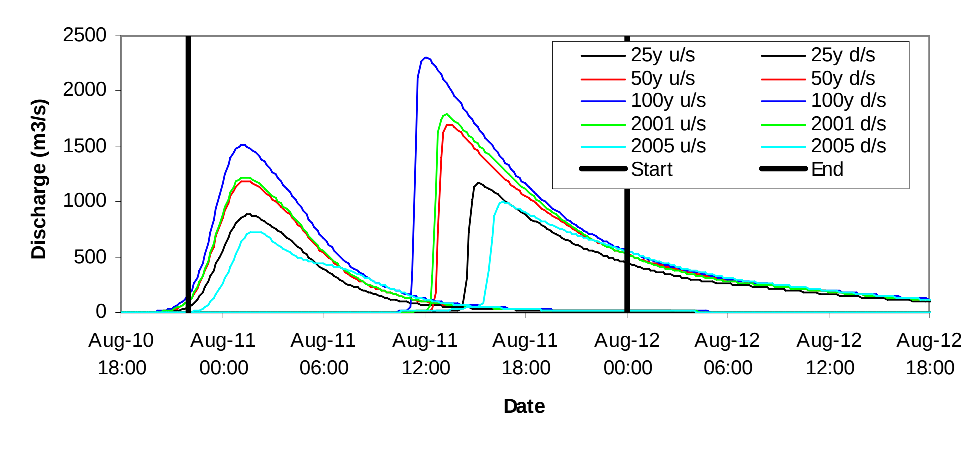

Fig. 2.122 Simulated Upstream Discharge and Downstream Discharge from the MIKE 11 HD Model

Note that each scenario starts on 10 August, except the 2005 flood that starts 9 August. For better representation the 2005 Flood was moved to start on 10 August in this figure. The simulation period to be used for the HD+ST models is selected as 10 August 22:00 to 12 August 00:00 (9-11 August for 2005 flood).

The HD+ST (Sediment Transport) simulations are CPU demanding. Thus it is important to cut the simulation period to only what is necessary. By looking at the results of the HD simulations as shown in Fig. 2.122, it is suitable for simulation for the period as 10 August 22:00–12 August 00:00. For the 2005 flood the period is moved two days back, i.e. 9-11 August.

Simulation Results

The debris model simulations are carried out both with and without debris flow included, which allows a quantification of the debris flow impact. The following results are presented herein:

- Temporal variation of the debris dams
- Bed and water level profiles
- Surging effect

(1) Temporal Development of the Debris Dams

The temporal development of the simulated debris dams is investigated for all the debris inflow points. As we have seen already, the tributaries peak at a couple of hours before the Madarsoo, and hence debris flow enters the river before the floodwater reaching. This means that the debris dams were formed before the floodwaters arrive. The following are investigation results through simulation when the debris dams are eroded.

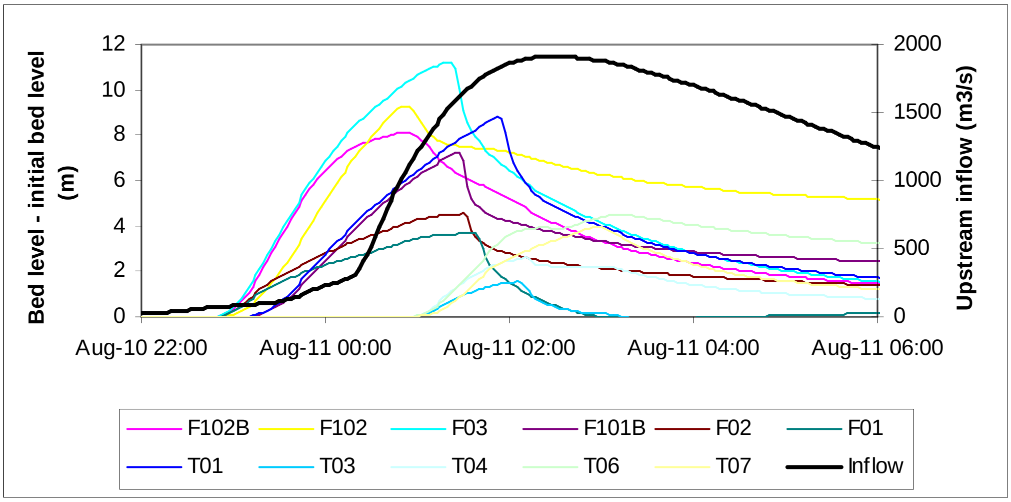

Fig. 2.123 Temporal Development of Bed Level Minus Initial Bed Level for All Debris Dams Shown along with Floodwater Inflow

Fig. 2.123 shows the temporal variation of the bed level in each debris inflow point where the initial bed level has been subtracted for better graphical presentation. It is seen that the debris dams are actually eroded before the 100-year flood peak arrives. Note how quickly the debris dams collapse when the discharge passes a threshold.

The timing of the erosion of the debris dams is sensitive to the calibration parameters, especially the sediment transport capacity. If lowered, the debris dams will last longer and cause more flooding.

The results suggest that the relative impact of debris flow will bigger for smaller flood events that cannot erode the debris dams on the rising limb.

(2) Bed Level and Water Level Profiles

Figs. 2.124 and 2.125 show the longitudinal profiles of the water level and bed level. The localized effect of the debris flow is seen clearly. Fig. 2.126 shows the difference between the two simulations (with and without debris flow). It is worth noting that the bed level difference is higher than the water level difference because the debris dams start eroding before the flood peak arrives. The backwater effects from debris deposits can be felt up to 1 km upstream of the debris deposit.

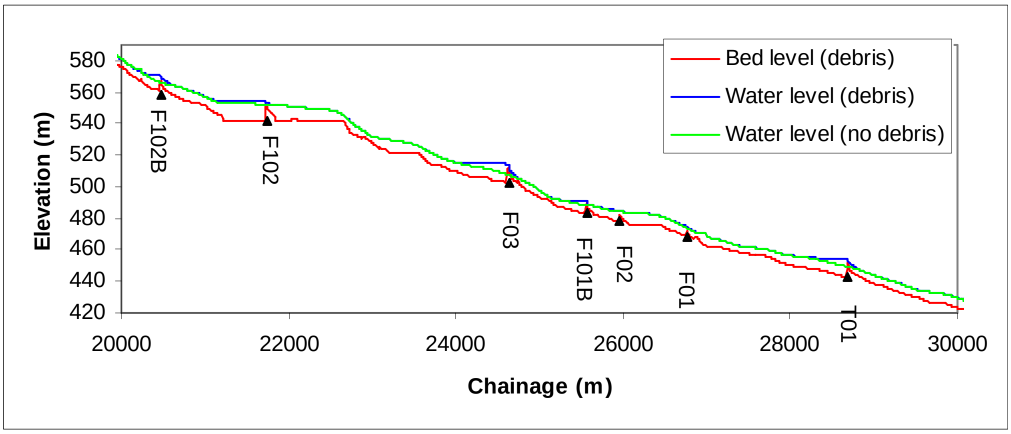

Fig. 2.124 Profiles of Maximum Floodwater Level (with and without Debris) and Maximum Bed Level (with Debris) for Debris Flow Simulation with 100-Year Event, Upstream Part of Local Debris Model

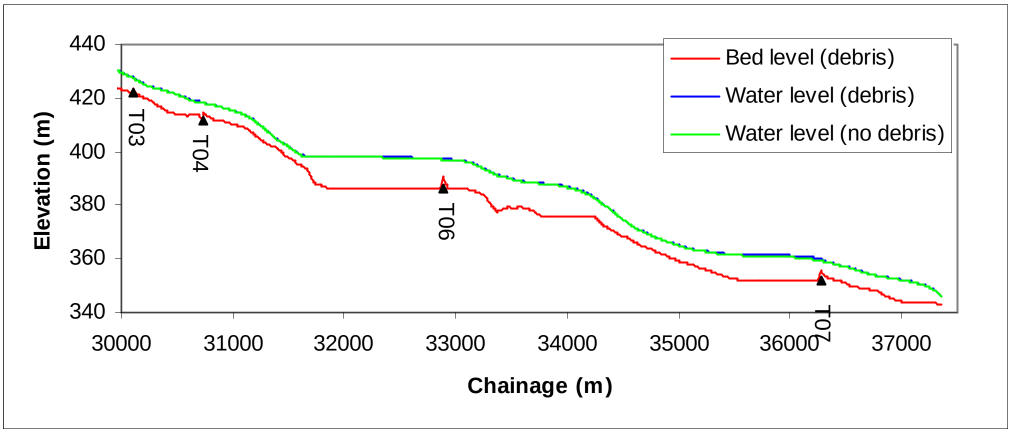

Fig. 2.125 Profiles of Maximum Floodwater Level (with and without Debris) and Maximum Bed Level (with Debris) for Debris Flow Simulation with 100-Year Event, Downstream Part of Local Debris Model

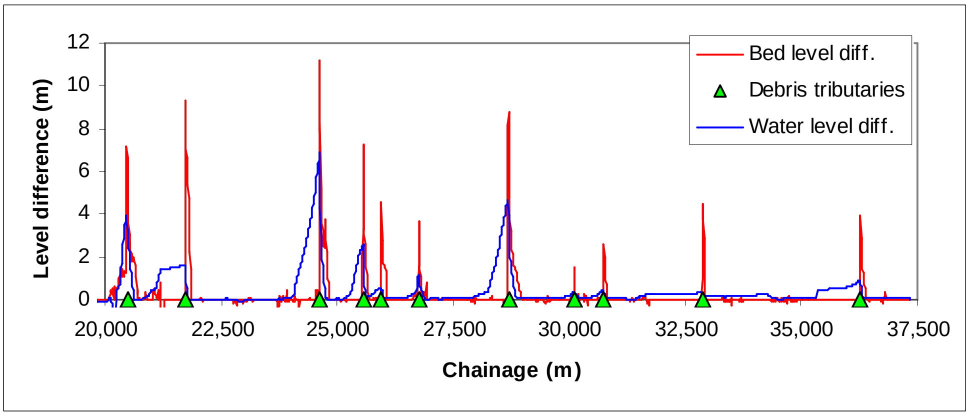

Fig. 2.126 Difference in Maximum Bed and Floodwater Level Caused by Presence of Debris Flow (100-Year Event)

(3) Surging Effect

During the initial phase of the flood where the debris dams are formed, the debris dams store some floodwater, which is released when the debris dams are eroded. The surging effect of the flood flow is quantified by looking at the temporal and longitudinal variation of the simulated discharge.

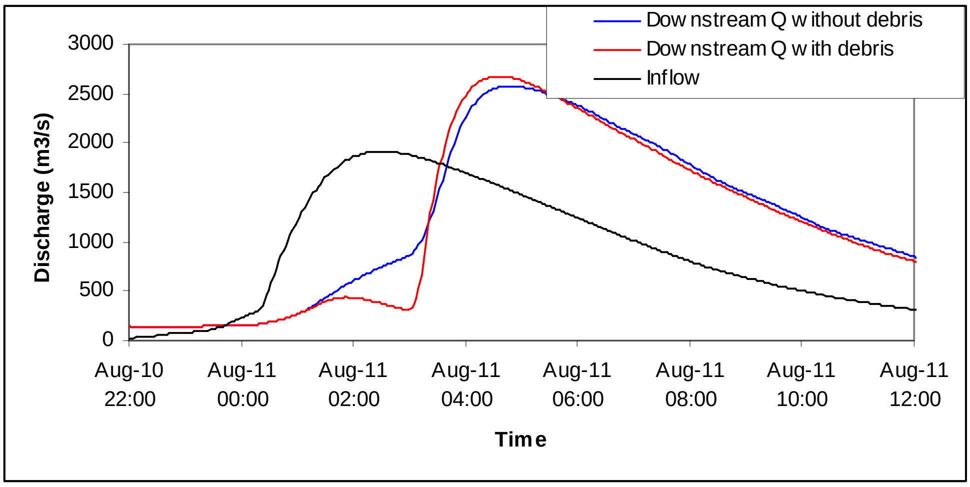

Fig. 2.127 Temporal Variation of Downstream Discharge in Local Debris Model with and without Debris Flow

The temporal variation of the discharge at the downstream end is investigated as illustrated in Fig. 2.127. The figure shows that the debris reduces the downstream discharge in the beginning of the flood, since water is held back behind the debris dams. The stored water is released as the debris dam is eroded by the floodwater, and the peak discharge increases about 100 m^3/s, which is not insignificant.

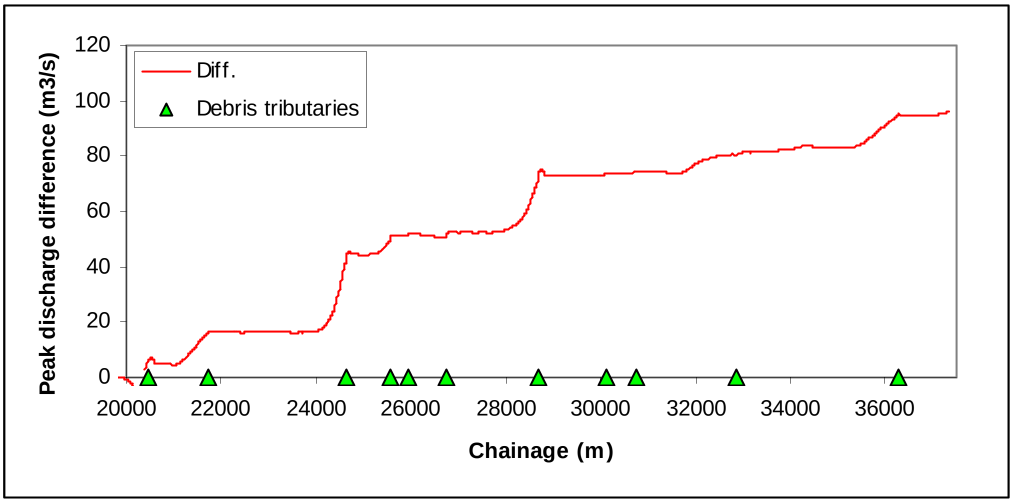

Fig. 2.128 Longitudinal Variation in Difference in Peak Discharge (with Debris Minus without Debris) down through Local Model

The longitudinal variation of the peak discharge is shown in Fig. 2.128. It is seen that each debris dam gives an increase in the peak discharge, and obviously the most important contributions are made by the large debris contributors, like F03 (24,633 m) and T01 (28,695 m).

The presence of debris flow is estimated with the model to increase the 100-year peak discharge by about 100 m^3/s downstream of the debris flow prone reach. The model shows that the debris increases the 100-year peak discharge in the downstream end of the debris prone area from 2,580 m^3/s to 2,676 m^3/s, which is an increase of 3.7 % in the peak flow.

2.16.5 Flood Maps and Flood Extent

The results of the HD+ST model are used for mapping the floods in MIKE 11 GIS. The flood map calculated with debris flow included is shown in Fig. 2.129. The flood map does not deviate much from what was already determined for this area with the HD model. Thus debris flow seems to be a secondary effect.

The effect of the debris flow was found by making a comparison map in MIKE 11 GIS, as illustrated in Fig. 2.130. Such map contains the difference in water depth between the two simulations, including areas where there is flooding with and without debris. The comparison map is shown in Fig. 2.131, and it shows what we have already seen from the water level difference (the flood maps are based on 2D maps of the 1D water level and the DEM), namely that the water depth will be increased locally behind a debris dam. The biggest impacts are found for the T01 and F03 tributaries with the water depth increasing more than 5 m. The F03 tributary is just downstream of a camping area in the Golestan Forest.

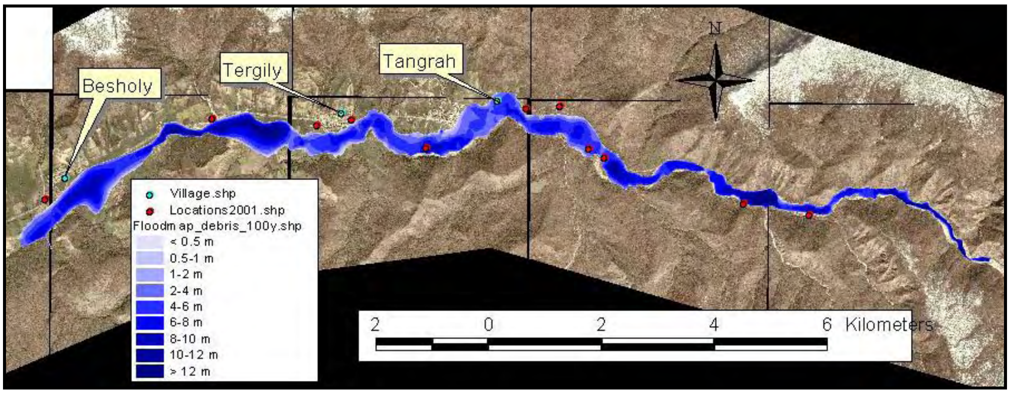

Fig 2.129 Flood Map for Local Model (100-year Flood, Maximum Flood Level) with Debris Flow

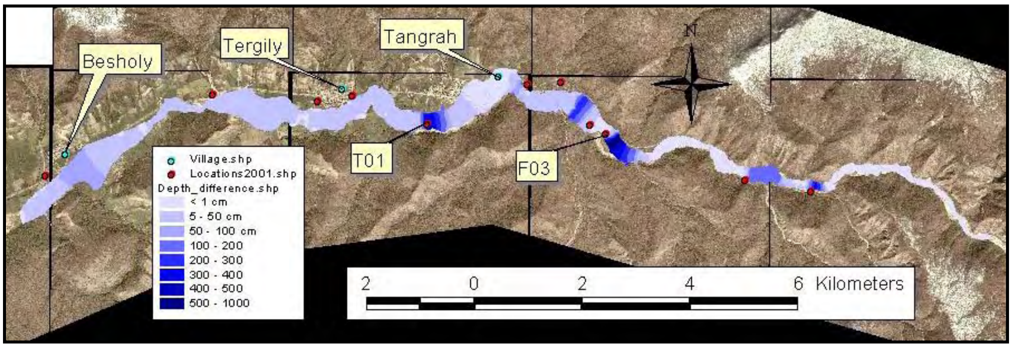

Fig. 2.130 Comparison Map (Maximum Depth with Debris Minus Maximum Depth without Debris) for 100-Year Flood

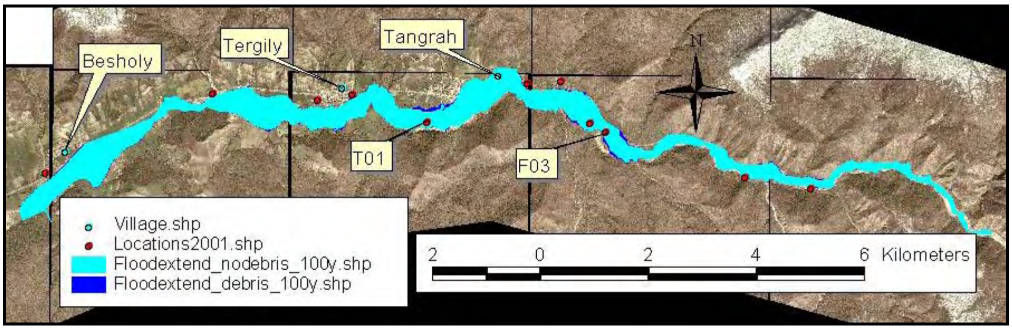

Fig. 2.131 Flood Extent with and without Debris Flow for 100-Year Flood

Finally the flood extent with and without debris is illustrated in Fig. 2.131. The impact of the debris flow in terms of flood extent is seen to be generally small. The flooded areas (100-year event) in the two cases are found from the flood extend polygons.

- 6,373,500 m^2 with debris flow
- 6,200,600 m^2 without debris flow

The length of the local model is 20,834 m, which gives an average width with debris of 306 m and without debris of 298 m, and an impact of the debris of 8 m increase in width, or 2.8% (also for the flooded area).

CHAPTER 3 FORMULATION OF MASTER PLAN

3.1 Basic Frame of Master Plan

3.1.1 Goal and Objectives

In two consecutive years of 2001 and 2002, and recently the year of 2005, the severe intensive downpour occurred in the Madarsoo River basin. Triggered by torrential downpour in August 2001, visitors of the Golestan Forest as well as residents in the basin suffered severe damages from the tremendous flood and debris flow not previously experienced. After learning irreplaceable lessons in both floods, lots of improvements have been made over the disaster management fields by the relevant organizations in the Golestan Province.

The master plan for flood and debris flow mitigation and management shall cover the entire fields and shall integrate the efforts being made by the relevant organizations. Thus the master plan shall be comprehensive including entire process of disaster management: preparedness, urgent response, recovery and development, and prevention and mitigation.

In due consideration of the above situation, the goals and objectives could be set up as illustrated in the following figure.

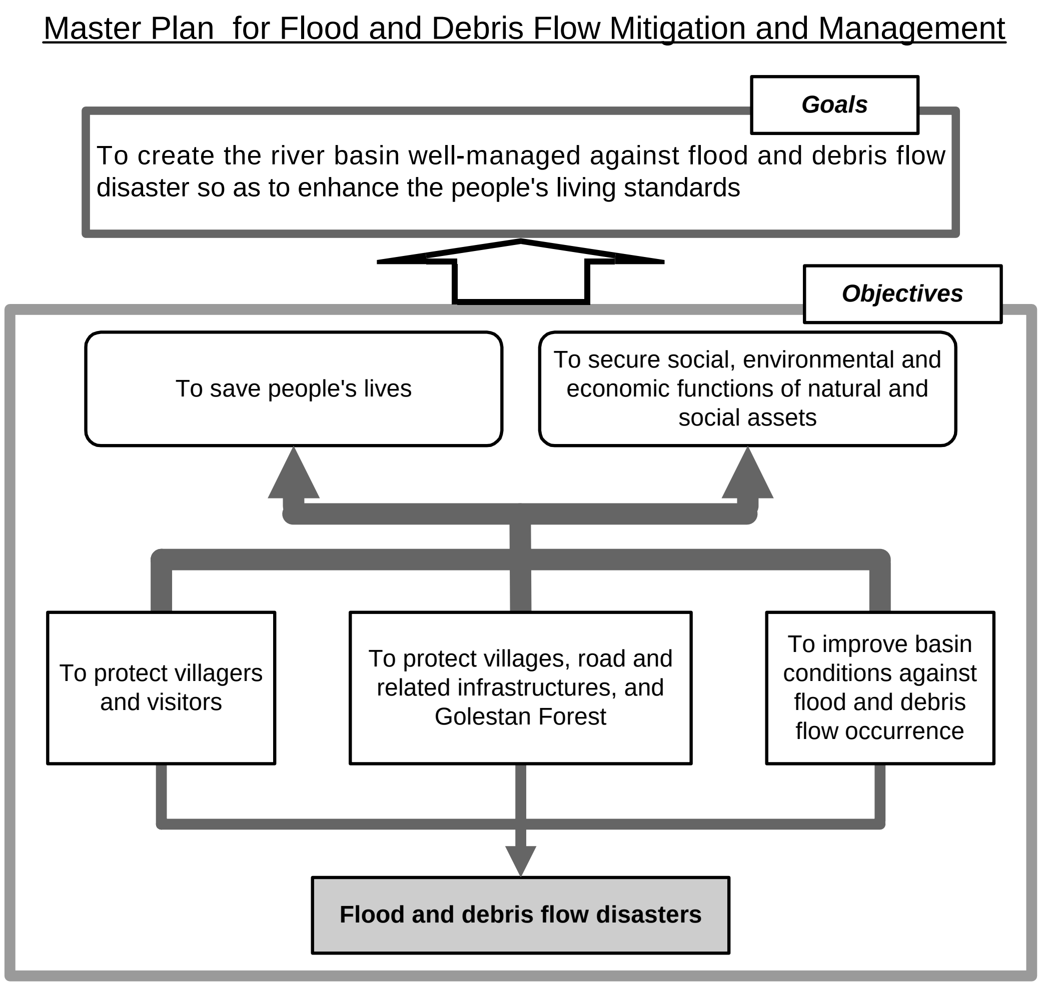

Fig. 3.1 Goals and Objectives of the Master Plan

The above figure shows the conceptual structures of the master plan for flood and debris flow mitigation and management.

The Goals are:

"To create the river basin well-managed against flood and debris flow disaster so as to enhance the people's living standards".

It implies that only minimal and tolerable damages cloud be admitted in the basin during the design flood. In order to realize such goals, the following two objectives shall be pursued at least:

(1) To save people's lives, and

(2) To secure social, environmental and economic functions of natural and social assets.

Following the goals and objectives, the master plan shall cover the wide fields in space and time and integrate the protective, remedial and improving measures against flood and debris flow.

3.1.2 Target Year and Phased Implementation

As agreed in the scope of work meeting in September 2003, the target year of the Master Plan shall be set in the year 2025 (Iranian Year 1404). This would be divided into two or three periods for phased implementation of the master plan after its formulation. For instance, the first phase is set for urgent implementation of priority projects, and the remaining phases are allocated for remaining works of the master plan.

3.1.3 Hydrological Design Scale

With reference to required design scale in Iran, the following safety levels for flood control planning are usually adopted in accordance with basin situations:

- Urban area: 50- to 100-year flood
- Rural area: 25-year flood

In due discussion with MOE-Golestan on the design scale in their planning, 100-year flood was adopted for the master plan in the Madarsoo River basin, while 50-year flood was adopted for the urgent project. In conformity with the standard of Iran and MOE planning, the following hydrological design scales are adopted in this master plan study.

- Protecting farmlands and rural villages: 25-year flood
- Protecting important structures (trunk road and bridges) and town areas: 100-year flood

This design scale concept is illustrated in Fig. 3.2.

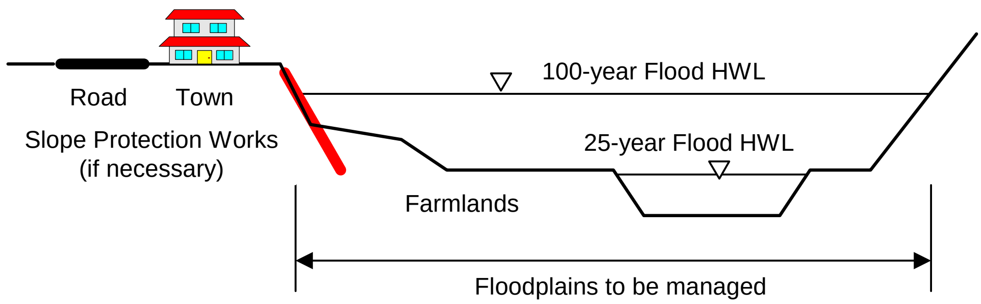

Fig. 3.2 Hydrological Design Scale Adopted in the Master Plan

3.1.4 Basic Concepts for Master Plan Configuration

As described in Section 3.1.1, the master plan shall cover the wide fields, mainly focusing on from flood and debris flow occurrence to disaster breakout, in space and time. This means that various types of countermeasures shall be comprehensively combined, which are not only suitable for sub-basin's natural conditions, climate, soil and topography but also totally preventive and curable to the process of disaster occurrences, rainfall to runoff, flood and debris flow. Fig. 3.3 illustrates this idea.

Spatial extent of the basin can be broadly divided into three characterized areas. These are summarized in the following table.

Table 3.1 Comprehensive Flood and Debris Flow Mitigation and Management Components

Area	Natural/Social Features	Suitable and Effective Measures	Additional Effects
Headwaters	Small amount of rain	Source control (rain, soil)	-Groundwater recharge
	Mild mountain slope	-Land treatment	-Increase of crop yields
	Mild declining plain	-Biological measures	-Increase of husbandry capacity
	Rural villages	-Flood retention	
Mountain Valley	Large amount of rain	Source control (rain, soil)	-Protection of natural forests and land use
	Steep mountain slope	-Land treatment	
	Narrow valley-bottom	-Biological measures	-Reduction of traffic damages
	Golestan Forest National Park	-Sediment/debris control	
		Flood control	-Groundwater recharge
	Many visitors and campers	-Bank protection	
Floodplains	Intermediate amount of rain	Flood control	-Avoidance of extreme damages
	Mild or no hilly area	-Bank protection	
	Flat and wide terracing	-Protection of infrastructure	-Accumulation of resident's knowledge
	Villages in upper terrace	Floodplain management	
	Granary in both terraces	-Land use control	
		-Flood hazard map	
Entire Basin		Flood Preparedness	-Continuing education for disaster preparedness
		-Early warning dissemination	
		-Placement for evacuation	
		-Training for emergency	

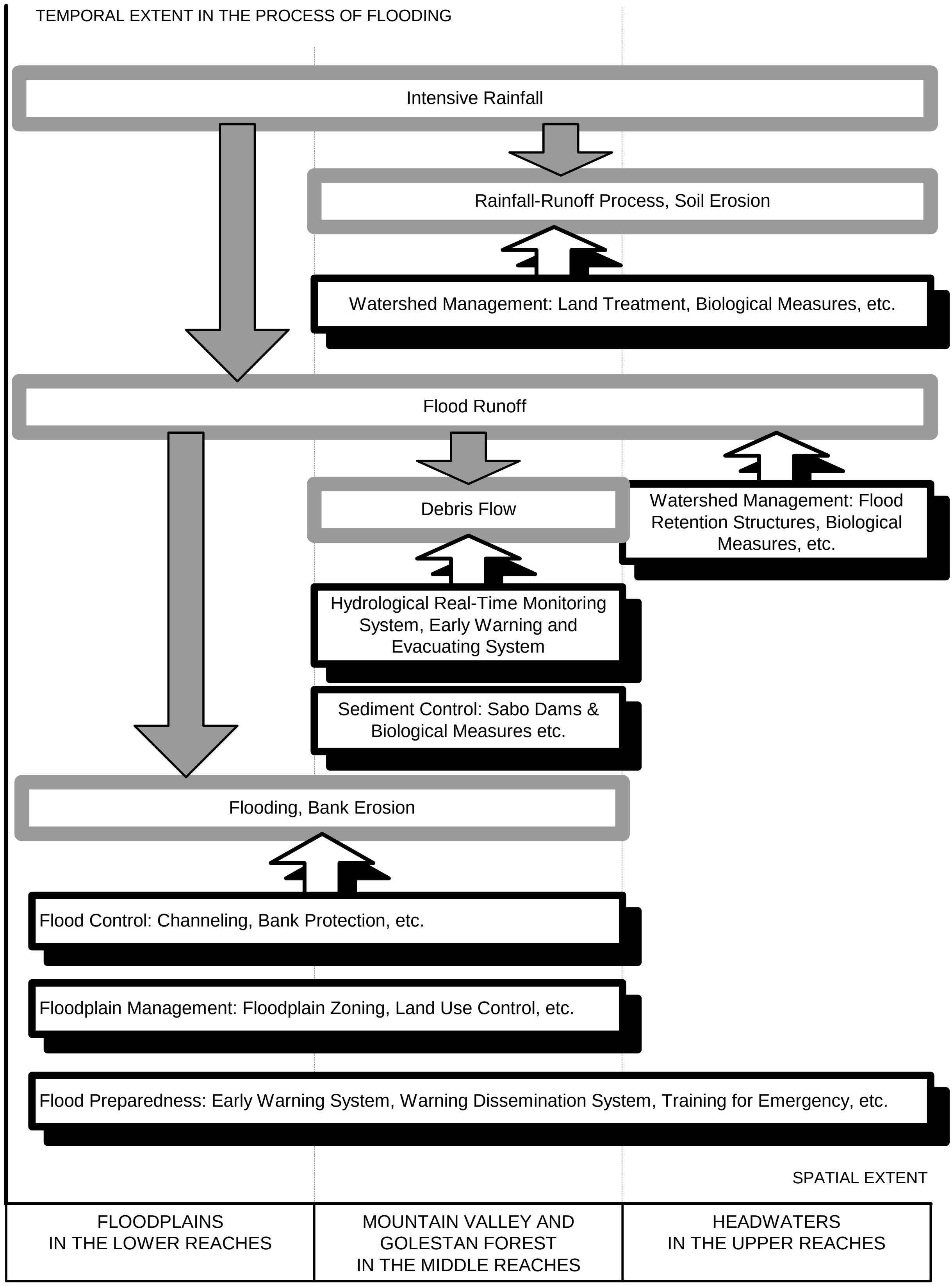

Fig. 3.3 Master Plan Components to Cover Temporal and Spatial Extents of Flood and Debris Flow Occurrence

3.1.5 Master Plan Components

Based on the above discussion, the selected countermeasures, which could be arranged to cope with flood and debris flow in space and time, shall be combined for the master plan components as supporting sub-schemes. These countermeasures could be organized into master plan components considering area by area, from upper to lower reaches, for easy understanding. The following figure illustrates the master plan components to be proposed.

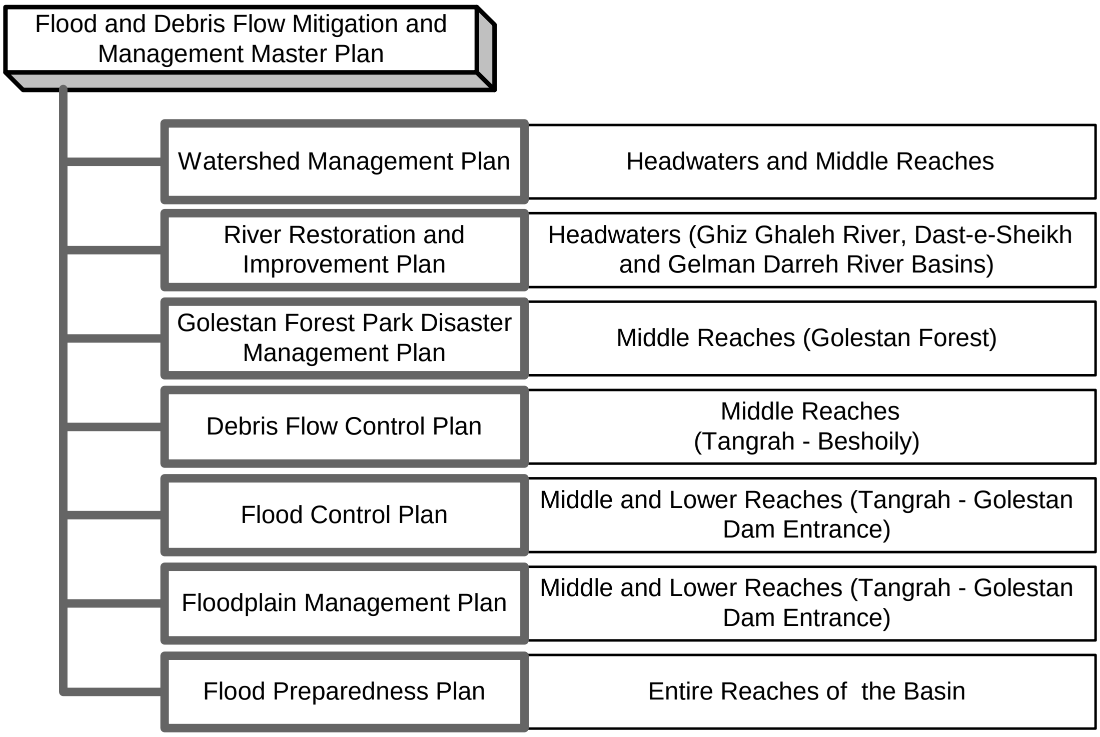

Fig. 3.4 Components of Master Plan for Flood and Debris Flow Mitigation and Management

(1) Watershed Management Plan

The headwaters of Madarsoo River could be divided into four sub-basins, namely Cheshmeh Khan, Nardein-Sefid Daly-Gelman Darreh, Dast-e-Sheikh, and Ghyz Ghale from the east. In addition to these areas, the mountain and hilly areas in the middle reaches, from Dasht junction down to the end of hilly area, shall be also a target for Watershed Management Plan. The plan shall be formulated through review of watershed management master plan prepared by MOJA and mutual discussion with counterparts.

From flood control aspects, this plan contributes attenuation of runoff peak and volume and retardation of lag-time by combination of increase of infiltration capacity and increase of onsite rainfall-retention functions. Furthermore, from sediment/debris flow control aspects this plan contributes reduction of potential occurrence of debris flow due to decrease of sediment yields as source material of debris flow.

(2) River Restoration and Improvement Plan

Compared with Cheshmeh Khan, Nardein-Sefid Daly-Gelman Darreh sub-basins, Dast-e-Sheikh and Ghyz Ghale sub-basins are receiving relatively much more rainfall. In addition to the natural attribute, two dams in the Dast-e-Sheikh basin and two dams in the Ghyz Ghale basin were constructed before the 2001 Flood. During the 2001

Flood, all of the dams were breached and their water storage and flood/sediment control functions were completely lost.

In this context, some restoration plan in Dasht area is necessary so as to consolidate the stored sediment in the river channel, to control floodwater, to discharge floodwater safely through newly proposed channel system including the Gelman-Darreh River, and to increase the groundwater and sub-surface water recharge into the aquifer. This plan also needs a good coordination work with MOJA counterparts.

(3) Golestan Forest Park Disaster Management Plan

The Golestan Forest Park area is the most disastrous part in the Madarsoo River basin, as demonstrated in the 2001 Flood.

In the 2001 Flood, around 200 visitors and campers died in the park. Most of the camping sites are situated on the previous debris flow deposits due to flat topography, and usually campers and visitors enjoy its natural environment extending over 15 km along the riverbank. In the 2001 flood, debris flow occurred in the six mountain streams in the park. Debris flow in five streams out of six attacked the camping sites. Furthermore extremely large floodflow coming from the upper stretch simultaneously swept away visitors and campers as well as natural forest alongside of the Madarsoo River course in the park.

According to geomorphological study through aerial photo interpretation, landslide-prone areas extend widely in the most tributaries' basin in the Golestan Forest Park. These areas have potential to yield the sediment source of debris flow. Therefore it could be considered that the most tributaries have also potential to produce disastrous debris flow.

In due consideration of the above situation, Golestan Forest Park Disaster Management Plan shall contain the following improvements at least.

- Early warning and evacuation plan for visitors and campers, and
- Traffic safety plan during floods.

Recently the large-scale flood attacked the Golestan Forest Park again on 10 August 2005. Beforehand MET-Golestan announced flood warning as their weather forecast, and related offices such as Police and DOE shut off the connection road and drove visitors out of the Park. As a result these activities achieved no casualties being affected by the 2005 Flood in the Golestan Forest Park. This fact may show the management direction mentioned above is the most appropriate measures for the Golestan Forest Park.

(4) Debris Flow Control Plan

In the area downstream of Tangrah (entrance of the Golestan Forest Park), there are several mountain streams with potential of debris flow occurrence. In fact, debris flow occurred in the five mountain streams in the 2001 Flood. Three residents died due to debris flow in Tergenly village at that time.

Thus debris flow control measures shall be planned in these streams in combination with the said watershed management plan. This plan also needs a good coordination work with MOJA counterparts.

(5) Flood Control Plan

Flood control, in particular bank protection in and around the housing area of villages and in immediately up and downstream stretches of bridges, shall be planned from Tangrah down to the entrance of the Golestan Reservoir. For structural designing of the bank protection and relevant structures, the design scale shall be set at 100-year flood, taking into consideration that a 50-year design flood was adopted for the urgent rehabilitation works.

This plan shall keep good conformity with the urgent rehabilitation works and the long-term flood control and road improvement plans prepared or being prepared by MOE and MORT. Therefore a good coordination work with MOE and MORT is required.

(6) Floodplain Management Plan

Meteo-hydrological attributes of the Madarsoo River floods are characterized as big differences between flood discharges in normal years and ones in excessive severe floods. Both of them show different order of magnitude, for instance around 20 to 100 m^3/s in normal years, and 1,650 m^3/s in 2001, 700 m^3/s in 2002 and 1,060 m^3/s in 2005 at Tangrah station.

Another topographic attribute is terracing by free meandering of the Madarsoo River course. In the floodplains, which extending in the Gorgan River basin as well as the Madarsoo River basin, villages are located on the upper terrace, while only farmlands are located on the lower terrace. Habitat segregation or selection could be traditionally made due to low population pressure. But in the lower part of the Golestan Dam, some part of Gonbad-e-Kavoos city is situated in the lower terrace, as a reference.

In due consideration of the above-mentioned two characteristics, the optimum way for flood control could be formulated with utilization of;

- river channel for average flood conveyance, and
- lower terrace as high-water channel for excessive flood conveyance.

In fact, existing river channel can accommodate annual maximum flood discharges of thirty-one (31) years in the recent thirty-three (33) years (since 1970 until 2002).

In order to realize the above flood control scheme, the floodplain management plan is indispensable. This plan includes;

- To delineate flood hazard area, which means high-water channel area in 100-year flood,
- To control land use in the flood hazard area, and
- To closely link to the flood preparedness plan, in particular early warning system.

(7) Flood Preparedness Plan

Flood preparedness plan including early warning system is indispensable to mitigate the damage against flood and debris flow, from the viewpoints of saving people's lives. The plan will contain the following sub-schemes;

- Meteo-hydrological monitoring network improvement,
- Early flood warning system,
- Warning dissemination system, and
- Training for emergency.

This plan has to keep close relationship with related plans in accordance with area characteristics, for instance;

- River Restoration and Improvement Plan for Dasht area,
- Golestan Forest Park Disaster Management Plan for Golestan Forest Park,
- Debris Flow Control Plan for villages of Tangrah, Tergenly and Beshoily,

- Floodplain Management Plan for the Floodplain area.

3.1.6 Socio-Economic Frame Forecast

Socio-economic frame in the target year of 2025 is forecasted for the basis of the Master Plan of the Study. Socio-economic frame is already discussed on population projection in 2.2.3 and on future land use in 2.4.5. Based on those analyses, Tables 3.2 and 3.3 show population projection and future land use, respectively.

Table 3.2 Present and Future Population in the Madarsoo River Basin

	Present	Future			
Year	2005	2010	2015	2020	2025
Madarsoo Basin	93,141	101,831	111,332	121,719	133,075
Population Density (Persons/ha)	0.39	0.43	0.47	0.51	0.56

Drainage area of the Madarsoo River is 236,400 ha, and kept constant.
Sources: JICA Study Team, Survey for Environmental and Social Considerations- October 2004 –June 2005
Statistical Yearbook of Golestan Province, Management and Planning Organization of Golestan- 2003

Table 3.3 Future Land Use in the Madarsoo River Basin in 2025

Land Use	Area (ha)	% of Total
Afforestation	1,840	0.79
Bare Lands	1,616	0.68
Desert	647	0.27
Dry Farming	34,095	14.42
Forest	67,371	28.50
Irrigated Farming	30,703	12.99
Lake	126	0.05
Rangeland	98,970	41.87
Mixed Dry Farming and Rangeland	141	0.06
Residential (Urban)	741	0.31
Others (limits of sites for structures, roads, observatory stations, etc)	150	0.06
Total	236,400	100.00

Source: Golestan Provincial Jihad-e-Agriculture Organization, GIS Section, with collaboration of JICA Study Team- September 2005.

3.1.7 Hydrological Setup

Following hydrological design scale described in Section 3.1.3, design floods are computed in a series of hydrological analysis as presented in 2.6.

<u>Probable Basin Design Rainfall</u>

Probable basin rainfall is estimated using 32 samples (1974 to 2005) by various probable distribution curves. Among them, Log-Pearson type 3 is adopted as a best fit distribution. Estimated 2-day probable rainfalls are tabulated below.

Table 3.4 Probable 2-Day Basin Rainfall

Return Period (year)	2-Day Rainfall (mm)
2	28
5	44
10	57
25	76
50	94
100	115
200	140

In accordance with the above estimation, recent historical floods in the Madarsoo River basin could be evaluated from recorded 2-day basin rainfall as follows:

- 2001 Flood (Aug. 10-11): 97 mm ➔ 55-year
- 2002 Flood (Aug. 12-13): 45 mm ➔ 5-year
- 2005 Flood (Aug. 9-10) : 75 mm ➔ 25-year

<u>Provable Design Floods without Projects</u>

Spatial and temporal distribution patterns of rainfall are derived from five historical large floods; namely 1988, 1992, 2001, 2002 and 2005 Floods. The design flood hydrographs of five flood patterns at Tangrah in 25-, 50-, and 100-year return period are presented below.

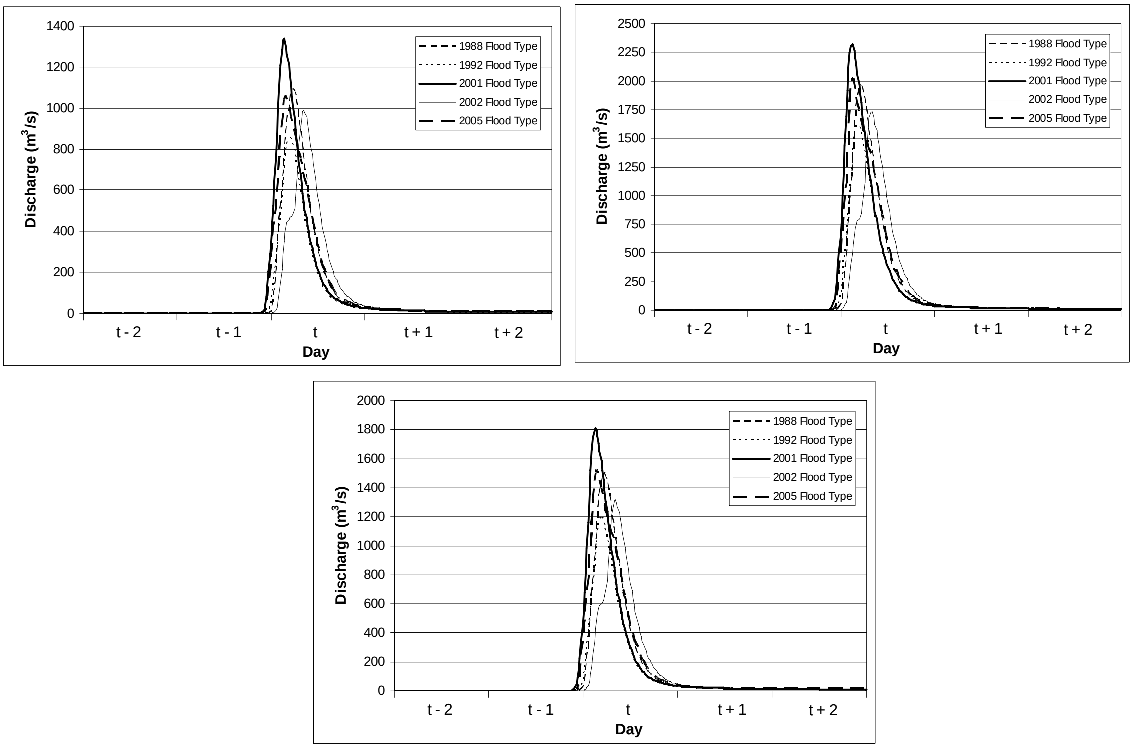

Fig. 3.5 Probable Flood Hydrographs at Tangrah in 25-, 50- and 100-Year Return Periods (from left to right)

Among five flood patters, peak flows generated with the 2001 flood type rainfalls are highest at all points along the mainstream. However, the peak discharge of 2001 flood type as presented in Fig. 3.5 is deemed to be too sharp and large. Further the 1988 flood type as the next largest discharge has not enough rainfall records. Therefore, it is suggested to select the 2005 flood type as a design flood for the flood control master plan development. In addition, rainfall records of hourly rainfall as well as daily rainfall were observed only in the 2005 Flood.

As a result, the design flood distributing over the Madarsoo River basin is illustrated below, including 50-year flood. These flood discharges are utilized as design discharge without projects after rounding up.

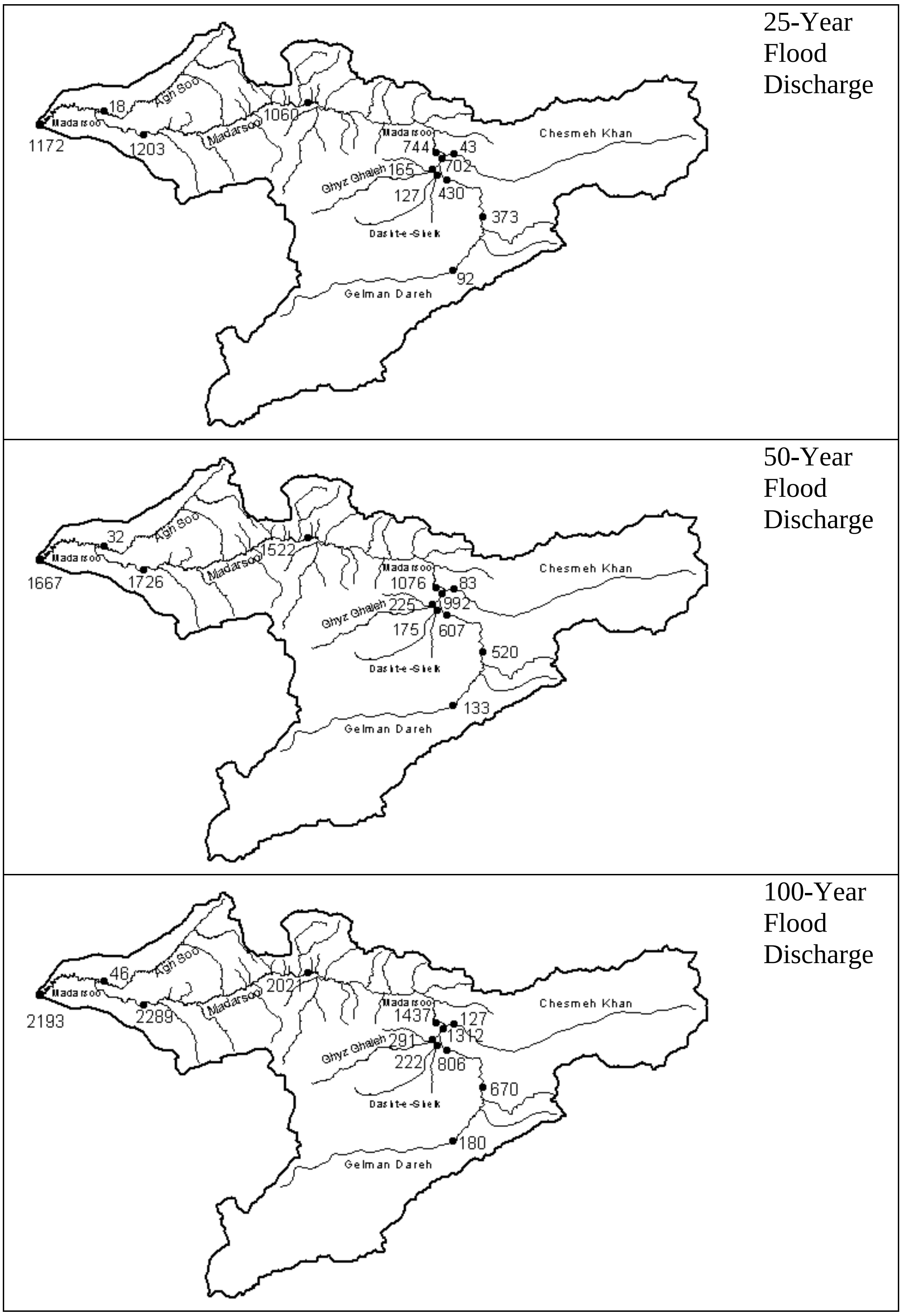

Fig. 3.6 Probable Discharge Distribution without Projects over the Madarsoo River Basin (2005 Flood Pattern)

Provable Design Floods with Watershed Management

The impact of watershed management practices like terracing, banqueting and furrow constructions and saplings plantation are analyzed. For this, area coverage of planned watershed management project in different sub-basins was collected (Table. 3.5). Coverage of the planned watershed management project was input in MIKE SHE hydrological model. Model parameters were adjusted accordingly for the areas and then generated flows in river system of basin. Manning’s roughness coefficient, detention storage, infiltration rate, LAI, interflow and percolation time constants were adjusted in the model for planned watershed management project areas to generate river flows for 25-, 50- and 100-year return periods.

Table 3.5 Coverage of Planned Watershed Management Projects

Item	Dasht-e-Shiekh	Ghyz Ghale	Tangrah	Chesmeh Khan
Terracing (Ha)	120	125	200	
Banquet (Ha)	1360	180	1740	145
Furrow (Ha)	2850		2650	
Plantation (Ha)		25	150	

Results show considerable impact of planned watershed management project in peak river flow as illustrated in the following figure. These results will be used for river restoration and improvement plan as basic design data.

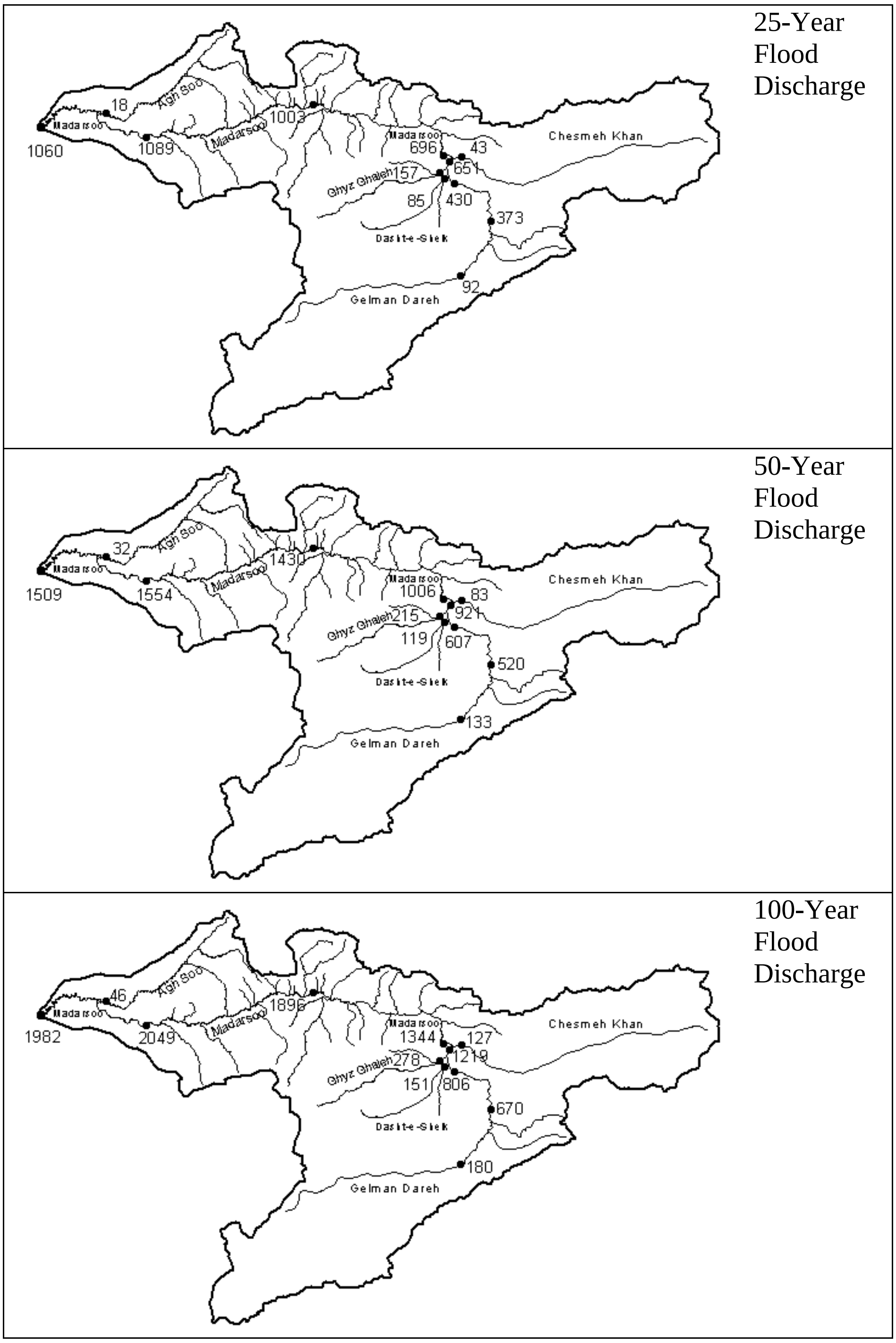

Fig. 3.7 Probable Discharge Distribution with Watershed Management Project over the Madarsoo River Basin (2005 Flood Pattern)

3.2 Watershed Management Plan

3.2.1 Purpose of Formulation of Watershed Management Plan

The purpose of the formulation of the watershed management plan is to review and evaluate the Implementation Plan prepared by MOJA, Golestan province in 2003. And it is to propose the improvement point to the Implementation Plan on the basis of the evaluation result.

Implementation plan consists of the following five sub-basins in the Madarsoo River basin. Fig. 3.8 summarizes locations of the sub-basin and countermeasures planned.

- □ Dasht-e-Sheik sub-basin,
- □ Ghiz Ghale sub-basin,
- □ Chesmae-Khan sub-basin,
- □ Tangrah sub-basin, and
- □ Loveh sub-basin.

3.2.2 Management Policy for Madarsoo Watershed

<u>Background of Implementation Plan</u>

Disaster of flood and debris flow was occurred in 2001, 2002 in the Gorgan River basin and many villagers and visitors fell victim to the flood and debris flow. After the disaster of flood and debris flow, Flood Control Committee was organized to coordinate the rehabilitation and prevention activities among the organization concerned.

MOJA dispatched the experts to the Gorgan River basin to investigate the disaster condition and arranged the issue of the rehabilitation and prevention of the Gorgan River basin. In response to the result of investigation, MOJA formulated watershed management plan to the Madarsoo River basin, which was seriously damaged in the 2001 Flood over the Gorgan River basin, under flood control committee.

In the Madarsoo River basin, MOJA selected the 5 sub-basins at the viewpoint of runoff, soil erosion, damage and so on, and MOJA formulated the implementation plan in these sub-basins. The position of the watershed management plan is one of the components of the master plan for flood and debris flow mitigation and management.

<u>Purpose and Strategy</u>

From implementation plan in different sub-basins the purpose and strategy of implementation plan arranged is summarized as follows.

Table 3.6 Planning Purposes and Strategies of Watershed Management

Purpose of Planning	Strategy of Planning
□ Increasing infiltration rate & decreasing runoff □ Increasing the vegetation cover in range land & forest areas □ Decreasing peak discharge of floods □ Soil conservation □ Improvement of life condition of people & increasing their income	□ Flood control and decreasing flood damage □ Sediment and soil erosion control

The implementation plan have planned and designed to bring the maximum effects of proposition based on the watershed management policy. Typical watershed management activities are classified into the following five (4) types:

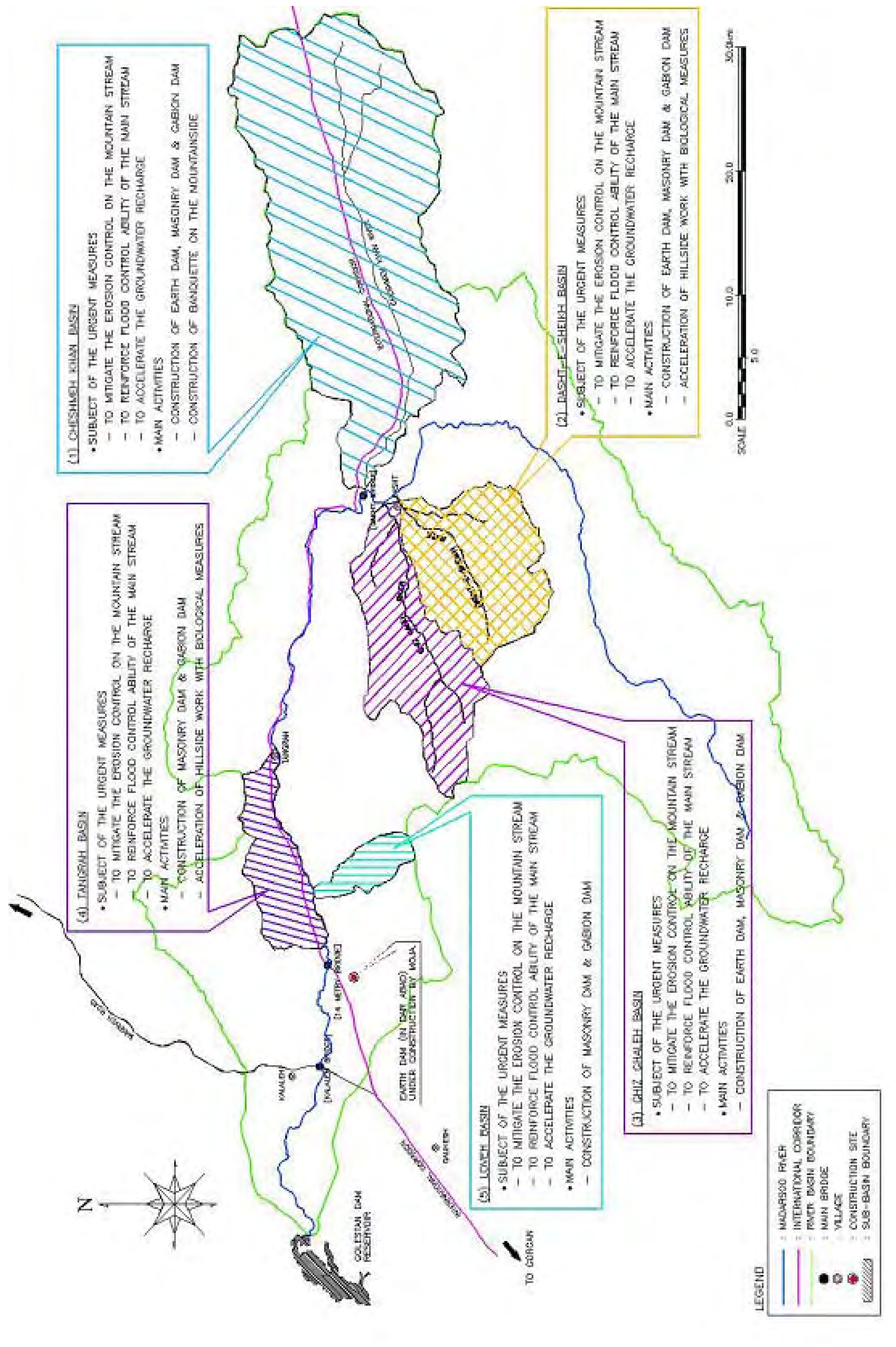

Fig. 3.8 Locations and Countermeasures Planned in the MOJA Mid-Team Watershed Management Plan

- Mechanical engineering
- Bio-mechanical engineering
- Biological engineering
- Protective activities

Function of Watershed Management Activities

(1) Mechanical Engineering

The functions of mechanical engineering works are:

Table 3.7 Summary of Mechanical Engineering Works

Countermeasure	Purpose
Gabion dam, masonry dam, earth dam and river engineering works	□ To prevent harmful sediment production in the headwaters of torrential streams □ To control sediment discharge in river course □ To protect the stream channel from bank erosion and/ or streambed scouring □ To confine the existing sediment deposit in the stream □ To avoid heavy bank erosion and streambed scouring in the downstream □ To decrease the flow impact □ To control or mitigate debris flow

(2) Bio-Mechanical Engineering

Bio-mechanical engineering works are countermeasures to protect soil erosion and runoff in dry farming and rangeland. The works are planned at a location of potential area of hillside degradation. Summary of bio-mechanical operation are as follow:

Table 3.8 Summary of Bio-Mechanical Engineering Works

Countermeasure	Purpose	Species for Planting	Species for Seeding	Number of Planting/ Seeding
Terracing	□ Increasing infiltration rate and decreasing run off □ Soil erosion control □ Creation of suitable agricultural land for wood and fruit production	Olive, Walnut, Corylus, Peach, Apple		140–200 N/ha
Banquette	□ Precipitation storage and runoff control □ Soil erosion control □ Increasing vegetation cover □ Increasing agriculture production □ Production of forage for livestock	Atriplex, Olive, walnut, Corylus, Peach, Apple, Atriplex	Medicago, Agropyron, Artemisa	140–200 N/ha
Furrow	□ Precipitation storage and runoff control □ Soil erosion control □ Increasing vegetation cover □ Production of forage for livestock	Atriplex	Agropyron Elengatum, Artemisa Siberica	5–10 kg/ha

(3) Biological Engineering

Summary of Biological engineering activities are as follow:

Table 3.9 Summary of Biological Engineering Works

Countermeasure	Purpose	Species for Planting	Species for Seeding	Number of Planting/ Seeding
Changing dry farming, strip cropping	☐ Increasing infiltration rate and decreasing run off ☐ Soil erosion control ☐ Increasing agriculture production ☐ Production of forage for livestock	Olive, Walnut, Corylus, Peach, Apple	Buffer crop like Alfalfa	200 N/ha (Corylus 1000 N/ha)
Fertilizing in range land	☐ Increasing vegetation cover ☐ Soil erosion control			50 kg/ha (Fertilizer)
Seeding in range land	☐ Increasing vegetation cover and decreasing runoff ☐ Soil erosion control		Artemisia, Astragalus, Kochia Sp.	5–10 kg/ha (mix)
Mass seeding	☐ Increasing vegetation cover ☐ Decreasing runoff ☐ Soil erosion control		Grasses, Medicago, Agropyron	1-3 kg/ha
Planting	☐ Precipitation storage and runoff control ☐ Soil erosion control ☐ Increasing vegetation cover ☐ Production of forage for livestock	Atriplex		225–335 N/ha
Tending forest, planting tree in the forest area	☐ Protection forest areas ☐ Increasing the number of appropriate forest species in the area that the forest were destroyed ☐ Creation of suitable place for promotion of eco-tourism, and conservation bio-diversity	Quercus	Acer	1,500-4,000 N/ha

(4) Protective Activities

Poor vegetation cover and soil erosion occurred by the overgrazing, extension dry farming and tree cutting. Protective activities are necessary for rangeland and forest rehabilitation. Summary of protective activities are as follow:

Table 3.10 Summary of protective Works

Countermeasure	Purpose
Enforcement of closures and maintenance	☐ Protection rangeland ☐ Protection forest areas ☐ Control grazing and vegetation improvement ☐ Forest and rangeland rehabilitation
Expelling sheep from forest area	☐ Rangeland management (vegetation improvement) ☐ Forest and rangeland rehabilitation ☐ Sustainable land utilization
Training and extension	☐ Introduction of watershed management activities ☐ Demonstration of the management system to villagers ☐ Establishment of the good relationship with villagers

3.2.3 Middle-Term Watershed Management Plan

Watershed management plan should be implemented in ten years. The project size in each sub-basin is tabulated as follows:

Table 3.11 Summary of Planned Mechanical Measures in the Selected Sub-basins

Counter Measures	Dasht-e-Sheikh	Ghiz Ghaleh	Tangrah	Loveh	Cheshmae Kahn
Earth dam	7N: Storage= $2.8x10^6$ m^3	18N: Storage= $2.8x10^6$ m^3			5N: Storage= 0.7 $x10^6$ m^3
Gabion dam	36N: 3,249 m^3	49N: 2,213 m^3	42N: 2,728 m^3	21N: 954 m^3	21N: 1,330 m^3
Masonry dam	35N: 24,105 m^3	25N: 38,659 m^3	9N: 5,700 m^3	6N: 2,595 m^3	36N: 1,276 m^3
River engineering			900 m		

Table 3.12 Summary of Planned Bio-mechanical and Biological Measures in the Selected Sub-basins

Counter Measures	Dasht-e-Sheikh	Ghiz Ghaleh	Tangrah	Loveh	Cheshmae Kahn
Terracing	120 ha	125 ha	200 ha		
Banquette	1,360 ha	180 ha	1,740 ha		145 ha
Furrow	2,850 ha		2,650 ha		
Changing dry farming	140 ha	500 ha			300 ha
Supporting drinking water for sheep	32 N	9 N			10 N
Fertilizing in rangeland	6,000 ha	2,700 ha			
Seeding in rangeland	4,200 ha	2,700 ha			
Mass seeding	240 ha	70 ha	180 ha		2,939 ha
Planting	4,104 ha	380 ha	180 ha		2,630 ha
Tending forest		60 ha	767 ha		
Cleaning (forest)		30 ha	42 ha		
Seeding (forest)		60 ha	35 ha		
Planting (forest)		25 ha	150 ha		

Table 3.13 Summary of Planned Protective Activities in the Selected Sub-basins

Counter Measure	Dasht-e-Sheikh	Ghiz Ghaleh	Tangrah	Loveh	Cheshmae Kahn
Training and extension	Farmers, range-men	1,000 person	1,200 person	1,250 person	
Enforcement of closures and maintenance	Implementation project area	85 ha of forest	4, 350 ha		9,418 ha
Fence in forest		28 km	15 km		
Building a channel		2 km	6 km		
Improving forest roads			28 km		
Existing sheep from forest area			6, 000 head		

3.2.4 Project Cost and Implementation Program

The project cost in each sub-basin is shown as follows. Total cost of the implementation plan is 79,374 million Rial.

Table 3.14 Average Unit Cost by Project Type

Type of project	Unit	Unit cost (Rial)
-Gabion dam	m^3	246,653
-Masonry dam	m^3	288,066
-Terracing	ha	28,107,299
-Banquette	ha	750,000
-Furrow	ha	250,000
		20,171,428
-Changing dry farming	ha	5,000,000
-Supporting drinking water for sheep	N	
-Fertilizing in rangeland	ha	90,250
-Seeding in rangeland	ha	156,000
-Mass seeding	ha	300,000
-Planting	ha	1,290,416
-Training and extension	lump-sum	600,000,000
-Enforcement of closures and maintenance	lump-sum	300,000,000
-Tending forest	ha	1,000,000
-Planting (forest)	ha	5,000,000

Table 3.15 Project Cost by Sub-basin

Year	Dasht-e-Sheik	Cheshmae Khan	Ghiz-ghaleh	Tangrah	Loveh	Total
1	10,110.7	349.4	8,373.1	9,621.7	1,114.5	29,569.4
2	3,459.6	804.4	4,767.5	1,592.5	62.5	10,686.5
3	3,151.7	445.3	7,338.2	1,077.2	62.5	12,074.9
4	3,848.3	845.7	3,000.8	1,215.5	62.5	08,972.8
5	5,121.1	575.3	3,222.5	1,557.2	62.5	10,538.6
6	2,717.0	372.2	-	1,050.5	-	4,139.7
7	180.2	465.0	-	888.0	-	1,533.2
8	180.2	323.3	-	1,160.0	-	1,663.5
9	-	194.9	-	-	-	194.9
Total	28,768.8	4,375.5	26,702.1	18.162.6	1,364.5	79,373.5

unit: million Rial

3.2.5 Evaluation of Countermeasures and Recommendations

After finishing the field survey, evaluation of countermeasures was made in adding knowledge of the existing project activities in Semnan Province and counterpart's opinions. The following are evaluation results and issues encountered in the field visit.

(1) Dasht-e-Sheik Sub-basin

In the Dasht-e-Sheik there are some issues such as site selection of banquette, procurement of the seedling to the furrow, understanding of local people and using fertilizer in the rangeland.

(2) Ghiz Ghaleh Sub-basin

In the Ghiz Ghale there are some issues such as construction cost of terracing, maintenance of the banquette and planting fruit trees, grazing control, chemical fertilizer using with mixed seed in rangeland and planting tree in the forest.

(3) Chesmae Khan Sub-basin

In the Chesmae Khan area there are some issues such as lack of the maintenance of banquette, grazing control, planting method.

(4) Tangrah

In the Tangrah area there are some issues such as lack of the training for terracing, the lack of incentive for strip cropping, selection of tree species and protection of the planting site.

(5) Loveh

According to the implementation plan in Loveh the mechanical engineering was proposed without biological engineering. So the evaluation has not conducted the field survey by using the checklist. But forest survey has been conducted in different forest type in Loveh sub-basin to examine the forest management system for the water and soil conservation.

On the basis of the above evaluation results, the following improvement points will be proposed mainly on biological measures and operational activities in the implementation plan.

<u>Terracing</u>

(1) Issues

The terracing in the dry farming is not so popular to the villagers. The reasons are as follows.

(a) Lack of the knowledge

(b) Lack of the visit to the village by the extension worker (trainer)

(c) Conservative and respect to their own experiences (Villagers believe that conventional method is cheaper than the terracing method.)

(2) Improvement

(a) Planting on the slope:

Perennial crop like a fodder tree will be planted on the slope between each terracing for the agriculture income and protection of the runoff and soil erosion.

(b) Coordination with agriculture extension worker (trainer) to introduce the terracing to the villagers

<u>Banquette</u>

(1) Issues

Gully erosion in the banquette occurred in the Dasht-e-Shekh sub-basin. The gully erosion seems to be caused by following reasons.

(a) Improper designing

(b) Lack of maintenance works

(2) Improvement

(a) Checking of storage capacity:

The rainfall shall be estimated before design and the banquette shall be divided into several parts along the contour line to avoid the water concentration.

(b) Appropriate density of banquette:

The banquette will be constructed according to the topography and inclination. It is also important to care the topographic conditions for design of the banquette on the upper part of the slope.

(c) Site selection for the maintenance

Encouragement of the Closure and Maintenance

(1) Issues

In the north west region of Iran the natural regeneration is the element of forest management. But it is difficult to regenerate and to maintain the forest by the overgrazing, farming and illegal cutting. Finally poor vegetation cover accelerates soil erosion.

(2) Improvement

(a) Delegation of forest maintenance:

The delegation shall conclude between NRGO and villagers to maintain the forest such as patrol in the surrounding forest, tending the forest (weeding, pruning). It is considered appropriate that NRGO gives the villagers land use right to get the incentive like a fuel woods in the forest.

(b) Cooperation with the villagers:

Through the extension and training activities, it needs to understand the forest function, especially water discharge and runoff. It is important to show the management system to the villagers.

Sustainable Forest Management

(1) Issues

From the recent trend of forest production in Iran forest production has been decreasing to protect the forest as the natural resources, biodiversity, water conservation, etc.

(2) Improvement

(a) Establishment of the goal for sustainable use:

The goal of the forest management needs to shift from the forest production to the water and soil conservation by appropriate zoning.

(b) Density control for selecting cutting:

NRGO has tried to introduce selective cutting system as new forest management system in Loveh forest management unit. The model project needs to establish the regeneration method, the logging method and cutting method for density control at the viewpoint of water and soil conservation.

Extension and Training

(1) Issues

Villagers attended the training course by MOJA, but they still have not understood the watershed management.

(2) Improvement

(a) Problem analysis in each sub-basin:

Problem analysis is one of the methods to clarify the problem of the villagers about water resources management, soil conservation and living conditions by using PRA (Participatory Rural Appraisal) method. At the same time necessary training shall be conducted to the villagers.

(b) Cooperation with agriculture extension workers:

Agriculture extension workers shall always contact to the villagers to improve their living conditions. Watershed management office needs to establish the good relationship with agriculture extension workers.

<u>Coordination with Other Agency</u>

(1) Issues

(a) Overlap of the boundary in the project area:

The implementation plan belongs to the three provinces, Golestan, North Khorasan and Semnan. MOJA staff in different provinces does not know other MOJA's activities of the watershed management in the same sub-basin.

(b) Some countermeasures in the Golestan National Park:

In Ghize Galeh and Chesimea Khan sub-basins, some countermeasures will be planed for water and soil conservation in the Golestan Forest National Park.

(2) Improvement

(a) Solution by Flood Control Committee:

Flood Control Committee has been established after the flood disaster in 2001 and 2002. This committee member consists of MOJA, NRGO, DOE, MORT, MOE, etc. in the provincial level. The chairman of this committee is from MOJA in Golestan.

Flood Control Committee should coordinate other related agencies on implementation plan, monitoring and evaluation of progress of the project.

(b) Good communication for conservation activities:

MOJA discussed with DOE in Semnan province to construct check dams in the protected area, and it took time to receive the permission. Originally the check dam has controlled the sedimentation from the upper part of the protected area. Thus DOE shall request MOJA to construct the check dams to the other sub-basins in the protected area.

3.3 River Restoration and Improvement Plan

3.3.1 Issues to be Addressed

Three large streams join in the flat topography of Dasht area. These are Gelman Darreh with a drainage area of 787 km^2, Dasht-e-Sheikh with 125 km^2, and Ghyz Ghaleh with 126 km^2. In the 2001 Flood, three disastrous events occurred in the Dasht area.

(1) Swollen floodwater along the Ghyz Ghaleh breached an earth dam located at 4 km upstream of Dasht village, and floodwater convolving stored sediment by the dam rushed towards the village area. After the 2001 Flood polder dike was constructed to protect the village from the direct hitting of floodflow.

(2) Larger and long-lasting floodflow came from the Gelman Darreh, and it washed away crops and fruit trees in the valley-bottom plain of Dasht area.

(3) Damming up might occur along the Madarsoo River at some upper part of the Golestan Forest during the 2001 Flood, and suddenly collapse due to overtopping floodwater. This rapid hydraulic change might induce serious channel scouring and bank erosion along the river course, and valley-head erosion around the upper end of water temporarily impounded area.

These locations in the Dasht area are depicted in the following figure.

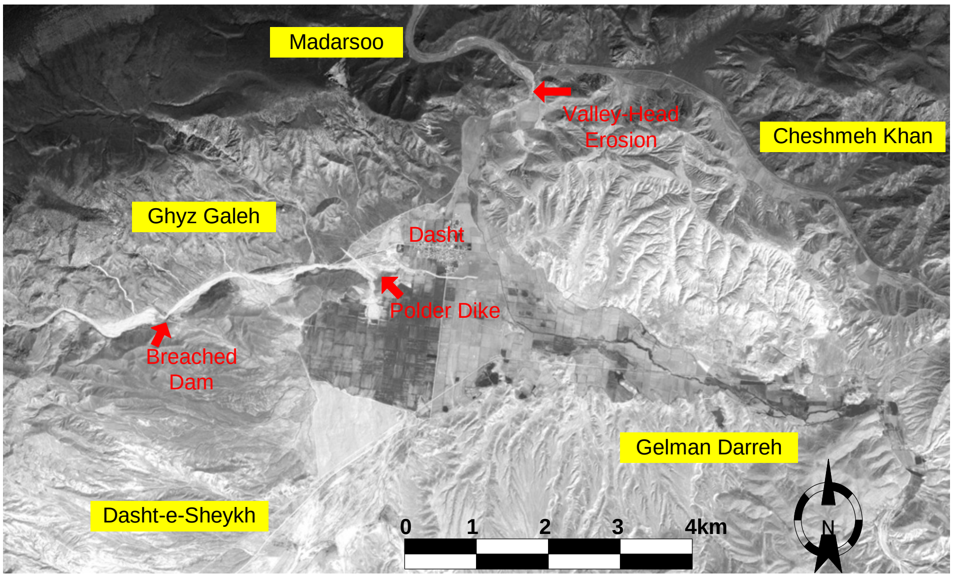

Fig. 3.9 Dasht Area (IRS Satellite Image)

In due consideration of the above mentioned situations during floods, the following three issues shall be addressed in the River Restoration Plan so that the Dasht village becomes safer and its agriculture-based economy becomes more productive.

(1) Sediment Consolidation in the Ghyz Ghaleh River

The left bank in the middle reaches of the Ghyz Ghaleh basin is the most devastated area in the Madarsoo River basin due to widely extending slope failures caused by deterioration and weathering of base rock. To protect Dasht village against floodflow hit, consolidation of stored sediment in the breached dam basin and controlling of excessive sediment during large floods shall be given a first priority. Otherwise transported sediment will accumulate around immediately upstream area of existing polder dike, and finally floodwater easily will rush to the village over the dike.

(2) Flood Control of Channel Network

As mentioned in 3.2 Watershed Management Plan, the hydrological effects of watershed management shall be premised for the flood control because of already progressing program. After land treatment such as terracing, banquette, furrow and reforestation, the design discharges of the three rivers in 25-year flood are tabulated below as discussed in 3.1.7 Hydrological Setup.

Table 3.16 25-Year Design Flood Discharge

unit: m^3/s

River	Design Discharge	Remarks
Gelman Darreh	430	
Dasht-e-Sheikh	90	
Ghyz Ghaleh	160	
Madarsoo	660	After confluence of the above three rivers

To ensure the reduction of the flood and crop loss in the widely extending farmlands, the river channel improvement shall be planned in parallel with watershed management practices.

(3) Erosion Control

As described above, valley-head erosion occurred in parallel with river channel degradation around the confluence with the Cheshmeh Khan River in the 2001 Flood. The valley-head height, which indicates the riverbed difference, is about 7 m from the existing riverbed to the upstream channel bed on topographical survey results.

In addition, the unstable riverbanks are prone to collapse and be eroded by flood flow and the erosion head progress some 50 m upstream in the 2005 Flood. Under this situation, some part of farmlands will be lost flood by flood. Thus erosion control measures such as a gully control dam or channel works shall be done in this area.

3.3.2 River Restoration and Improvement Plan

The proposed river restoration plan aims to protect the human life and private properties, and public infrastructures in and around Dasht village from the flood and/or sediment flow damages under the design scale of a 25-year return period as mentioned already.

The proposed plan contains the main countermeasures to enlarge the flow capacity and to strengthen channel bed stability and bank protection of the existing rivers against a probable flood.

The subject area is composed of the related three river systems; namely Gelman Darreh-Madarsoo River, Dasht-e-Sheikh River and Ghiz Ghaleh River. The proposed river system arrangement based on the probable flood of a 25-year return period is shown in Fig. 3.10 and the features of improvement of the related river system are described as follows:

Gelman Darreh-Madarsoo River

The proposed river improvement stretch of the Gelman Darreh including the Madarsoo River is from the confluence with the Cheshmeh Khan River to about 6.5 km upstream of the Gelman Darreh in accordance with the existing agricultural road crossing the river.

As regards the erosion control in the valley-head, the channel works is proposed to preserve the appropriate sediment conveyance from the headwater area for the downstream riverbed maintenance. If the sediment conveyance to the downstream of the river is limited with the storage capacity of a gully control dam or erosion control dam, it will be predicted that the downstream riverbed is degraded further by floodwater and the riparian structures along the Madarsoo River are damaged due to the loss of the foundation stability.

The improvement of the Gelman Darreh-Madarsoo River is mainly proposed to enlarge the channel width for the range from 64.0 m to 46.2 m and design high water level in the middle and upper reaches is set in accordance with the existing ground level as much as possible. The proposed channel alignment follows the existing stream alignment because the existing channel is located on the lower part comparatively in the Gelman Darreh floodplain and it is assumed to collect the floodwater easily over the subject area.

The high flow velocity occurrence for more than 4 m/s in the proposed Section Ge-1 to Ge-3, as shown in Fig. 3.10, is assumed based on the consideration of the proposed cross section with the uniform flow calculation under the design scale. It is predicted that the heavy channel bed scouring and bank erosion in a local reaches of the channel may be occurred due to the high flow velocity in case of the soil characteristics difference.

Therefore, in the detail design stage, it is recommended to carry out the careful consideration, including the probable flow velocity reduction as well as soil investigation, of the proposed design channel bed and channel bank stabilities against the probable high flow velocity, with the possibility for an introduction of a series of groundsills and/or suitable channel bed protection such as concrete block, gabion mattress and revetment expanding furthermore.

Fig. 3.11 and Fig. 3.12 show the typical cross section of the proposed Gelman Darreh-Madarsoo River and typical cross section of the proposed revetment works, respectively.

In addition, the existing bridge reconstruction in the middle of the stretch is proposed to maintain the existing agricultural road because of widening the channel. The typical cross section of the proposed bridge is shown in Fig. 3.13.

<u>Dasht-e-Sheikh River</u>

The proposed river improvement stretch of the Dasht-e-Sheikh River is located in the surrounding Dasht village farmlands for the distance of about 5.1 km to protect the farmlands from flood inundation due to Dasht-e-Sheikh River.

The improvement plan is mainly proposed to enlarge the channel width for the range from 58.2 m to 21.7 m and design high water level of the improvement stream is set in accordance with the existing ground level of the farmlands because the existing river shape of the Dasht-e-Sheikh River has been disappeared and when the new channel is planned in the torrential stream, the excavated channel is recommended by taking into account a reliability of flood control and an easy maintenance.

Fig. 3.14 and Fig. 3.15 show the typical cross section of the proposed Dasht-e-Sheikh River and typical section of the proposed revetment, respectively.

Furthermore, the high flow velocity occurrence at more than 3 m/s in the proposed Section Da-1 and Da-3 is assumed based on the consideration of the proposed cross section with the uniform flow calculation under the design scale. It is predicted that the heavy channel bed scouring and bank erosion in a local reaches of the channel may be occurred due to the high flow velocity in case of the soil characteristics difference.

Therefore, in the detail design stage, it is recommended to carry out the careful consideration, including the probable flow velocity reduction as well as soil investigation, of the proposed design channel bed and channel bank stabilities against the probable high flow velocity, with the possibility for an introduction of a series of groundsills and/or suitable channel bed protection such as concrete block, gabion mattress ands revetment expanding furthermore.

In addition, the new bridge construction is proposed to maintain the existing agricultural road because of the new channel excavation. The typical cross section of the proposed bridge is shown in Fig. 3.16.

On the proposed plan, the huge excavated material (V= approx.4.0 million m^3) may appear after the project implementation. The removal of surplus soil is recommended to reclaim in the immediately southern part of the proposed Dasht-e-Sheikh River because the area, which is spread for about 110 ha, has been devastated due to previous floods and there is a possibility of the development as new agricultural lands to increase the income for the Dasht villagers.

Ghiz Ghaleh River

Floodflow in the Ghiz Ghaleh River has directly attacked the Dasht village, frequently. The floods have sometimes caused the serious damages in human life and farmlands.

To prevent the damages caused by the flood and/or sediment flow in the Dasht village, the flood and sediment flow control facilities composed of the two structural measures are planned in the Ghiz Ghaleh River. The said two structural measures are diversion channel for the Ghiz Ghaleh River and sediment control dam. The arrangement of the proposed flood and sediment control facilities is shown in Fig. 3.17 and the design concept for the structures are mentioned below.

(1) Proposed Diversion Channel

In the 2001 Flood, the Dasht village has significantly sustained the flood damages including the victims caused by flood surging from the southern and western parts of the village through both rivers of the Gelman Darreh and the Ghiz Ghaleh.

The field reconnaissance clarifies the Ghyz Ghaleh River dose not have the confluence of the Gelman Darreh River or the Madarsoo River and the downstream end is replaced by the farmlands. It is assumed that the flood flow seldom occurs in and around the Dasht village before the 2001 Flood and the farmland reclamation and/or natural forces might make the river course bury gradually.

The proposed diversion channel aims to prevent the flood flow from spreading directly toward the Dasht village. The diversion channel is recommended that the watercourse of the Ghyz Ghaleh River is diverted to the southwest Dasht farmlands and the channel is connected to the proposed Dasht-e-Sheikh River in order to ensure the appropriate drainage channel system. Design discharge for proposed channel is adopted for 160 m^3/s under the design scale.

The control point of proposed diversion channel can be set on the existing excavated channel in the existing NRGO plantation, which is located at the right bank of 1.5 km downstream from the existing breached earth dam since the end of the existing channel has the natural diversion weir and it is possible that the floodwater run down to the Dasht-e-Sheikh River straight.

(2) Proposed Sediment Control Dam

The proposed sediment control dam is planned to rehabilitate a function of the existing earth dam, which has been breached by the 2001 Flood and to retain the sediment deposits of the existing earth dam at the original position in order to protect the Dasht village and its farmlands from the eroded sediment deposits.

The design scale of its spillway is provided with a 100-year return period and design invert elevation of its spillway (same as proposed dam height) is considered with the surface elevation of existing sediment deposits in the upstream.

The typical section of the proposed sediment control dam is shown in Fig. 3.18.

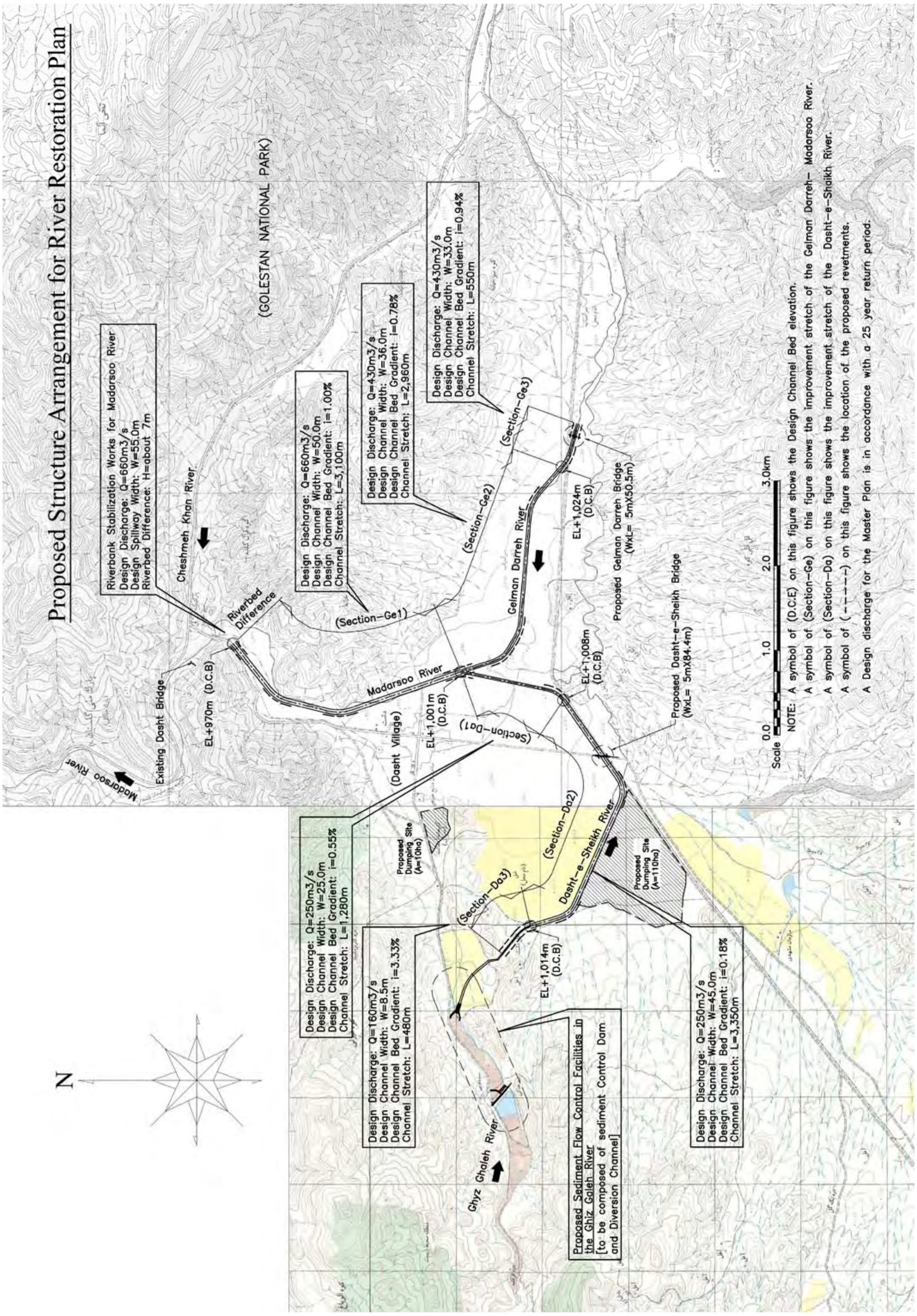

Fig. 3.10 Proposed Arrangement of River Restoration and Improvement Plan

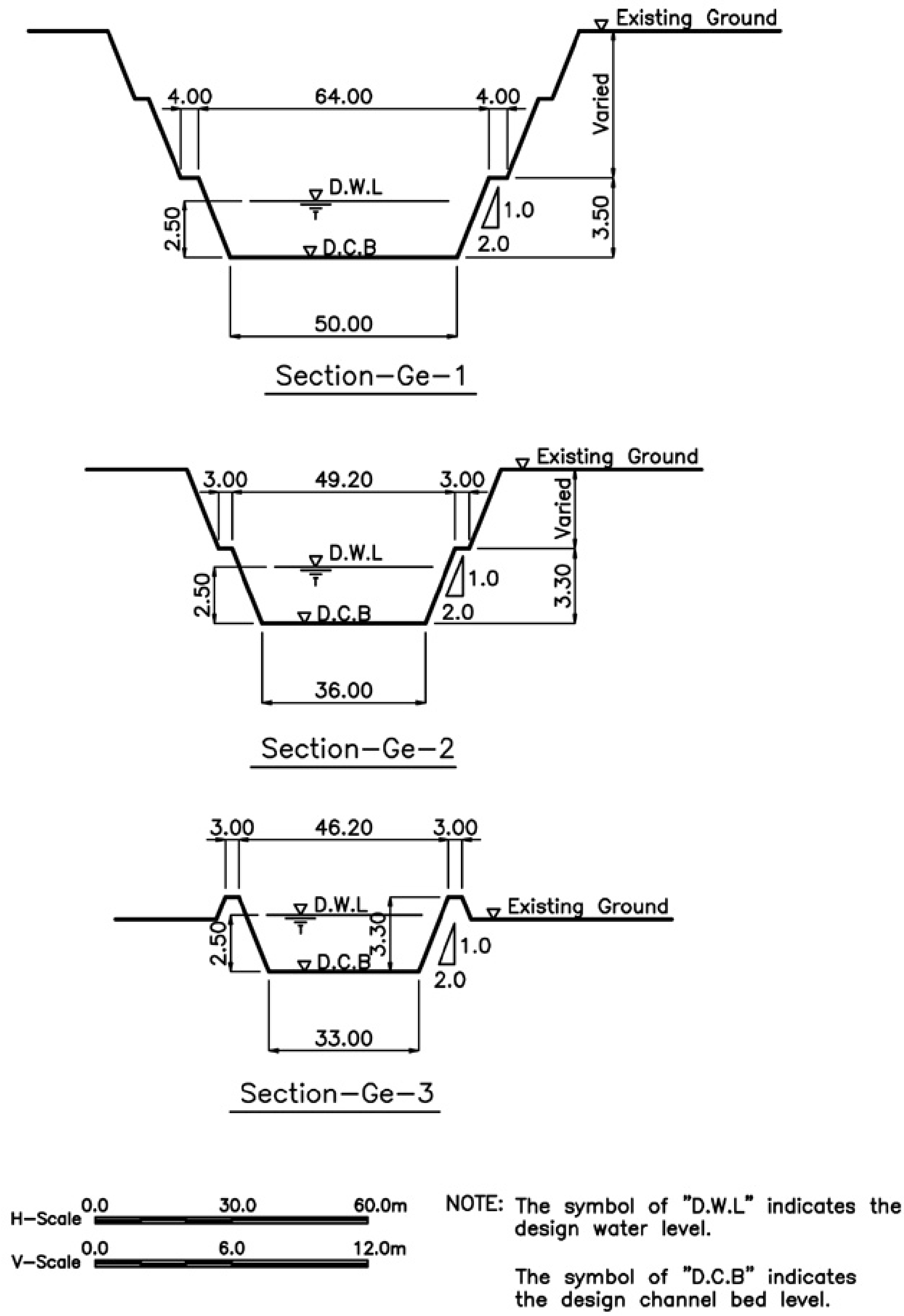

Fig. 3.11 Typical Cross Sections of the Proposed Gelman Darreh-Madarsoo River

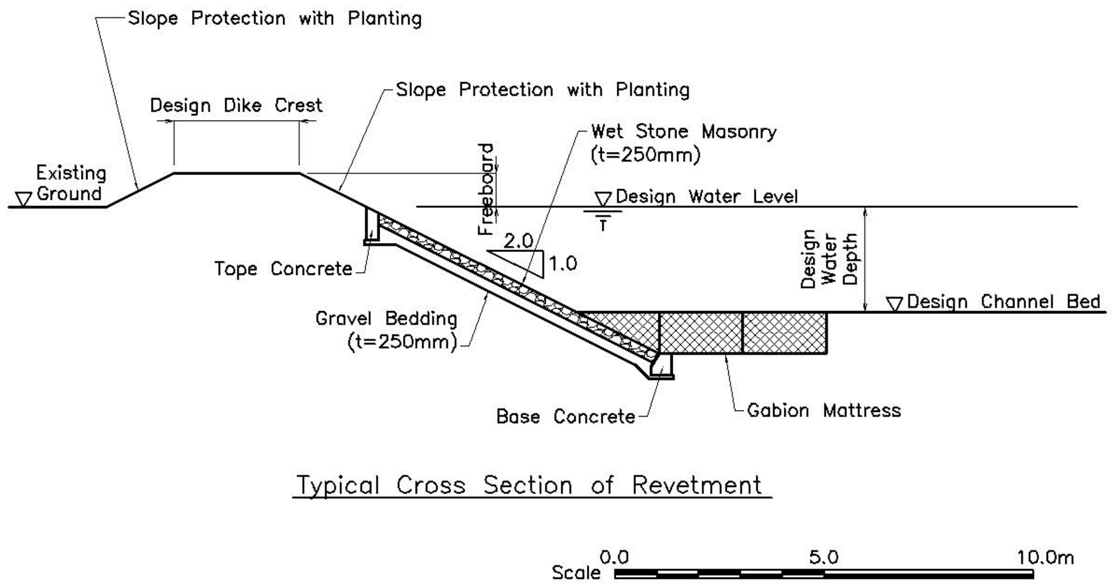

Fig. 3.12 Typical Drawing of the Proposed Revetment

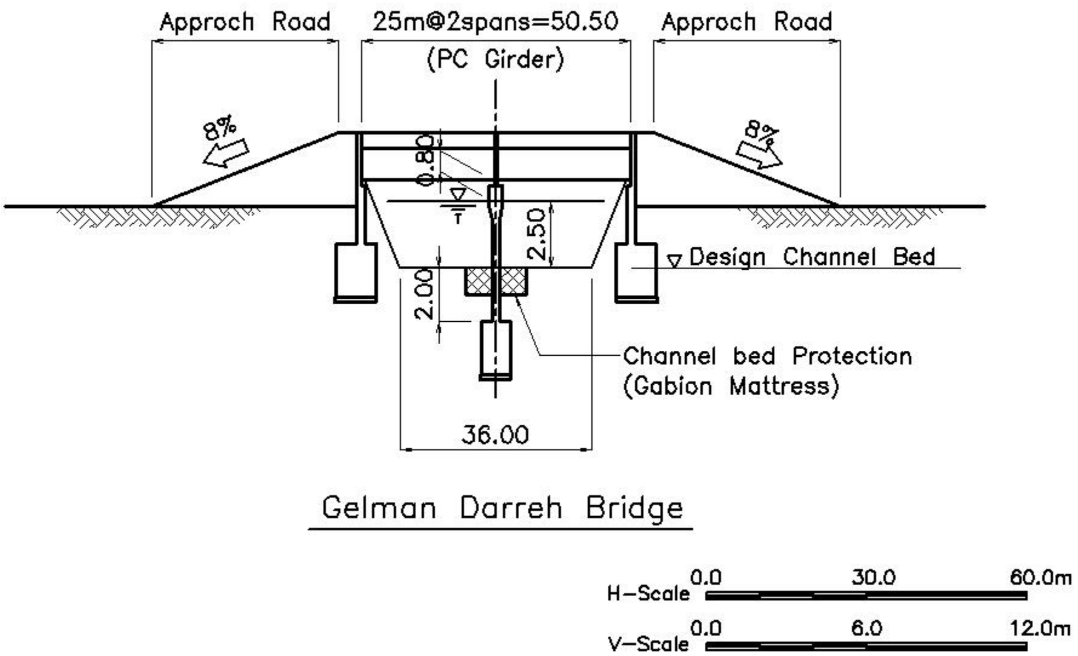

Fig. 3.13 Typical Section of the Proposed Gelman Darreh Bridge

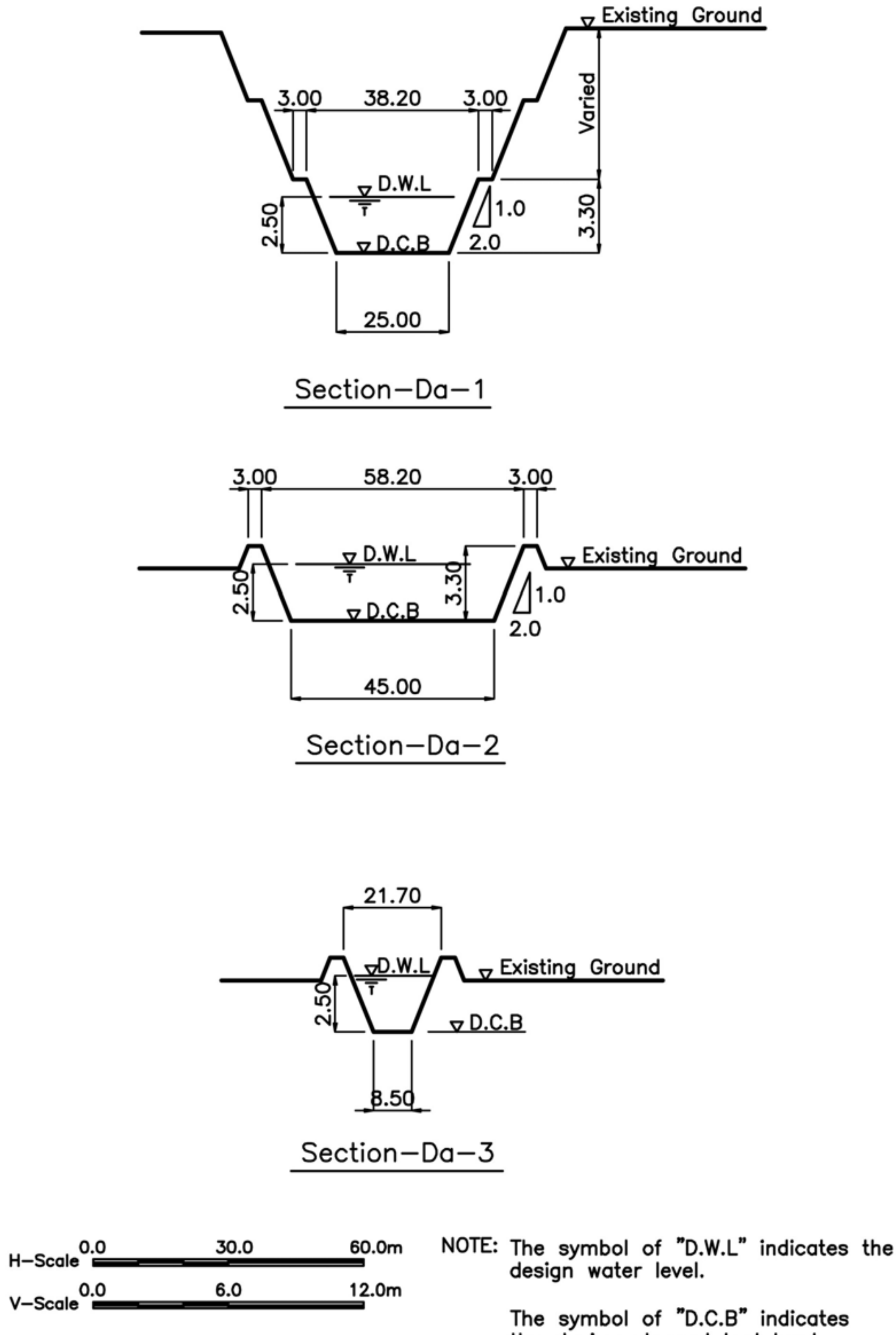

Fig. 3.14 Typical Cross Sections of the Proposed Dasht-e-Sheikh River

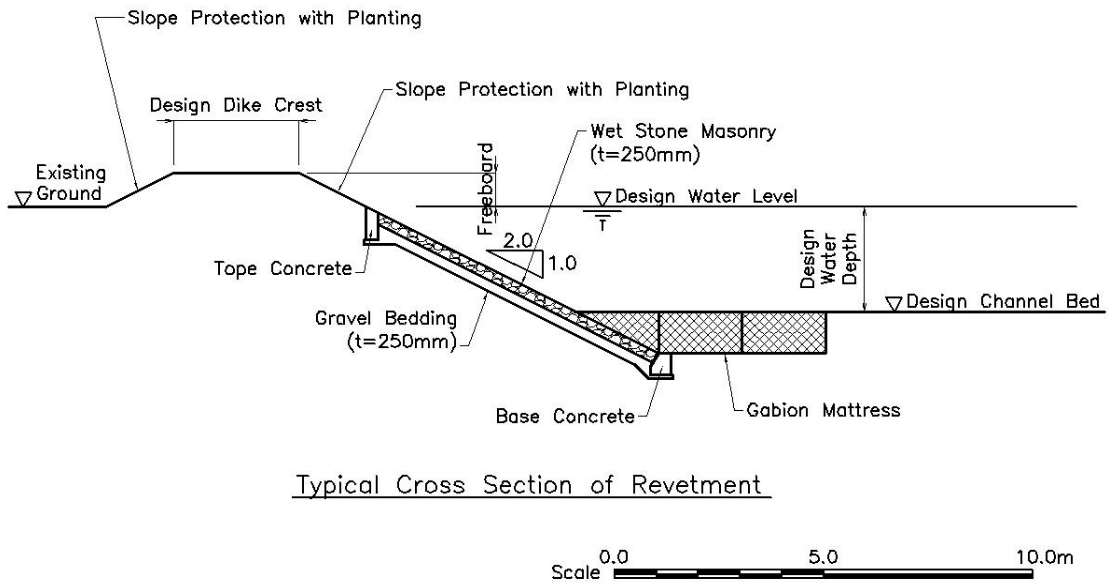

Fig. 3.15 Typical Drawing of the Proposed Revetment

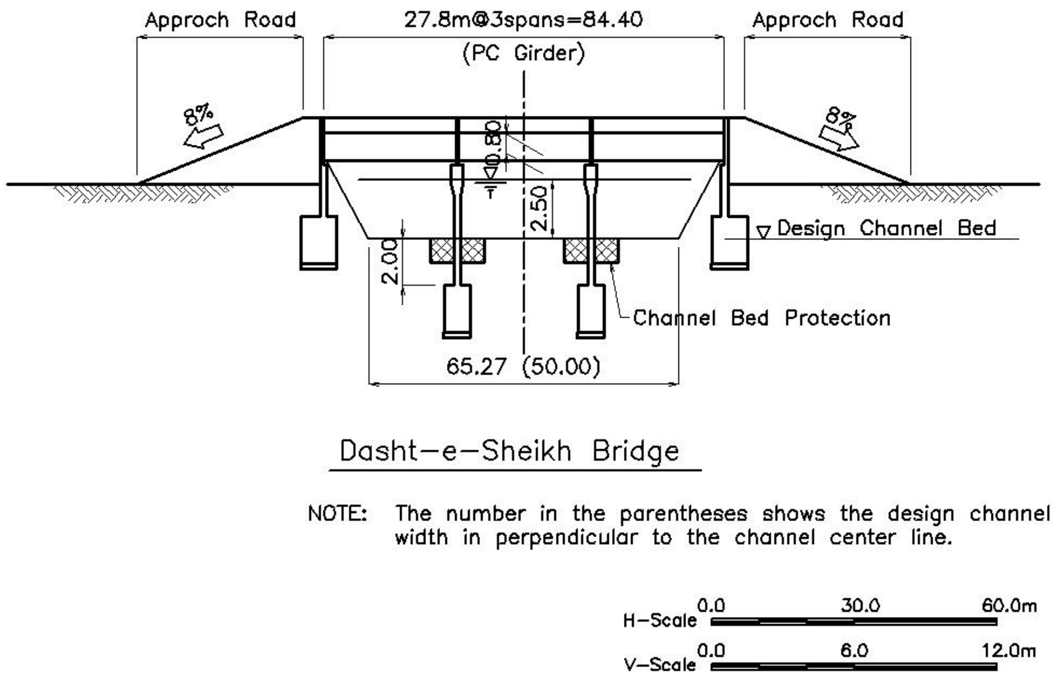

Fig. 3.16 Typical Section of the Proposed Dasht-e-Sheikh Bridge

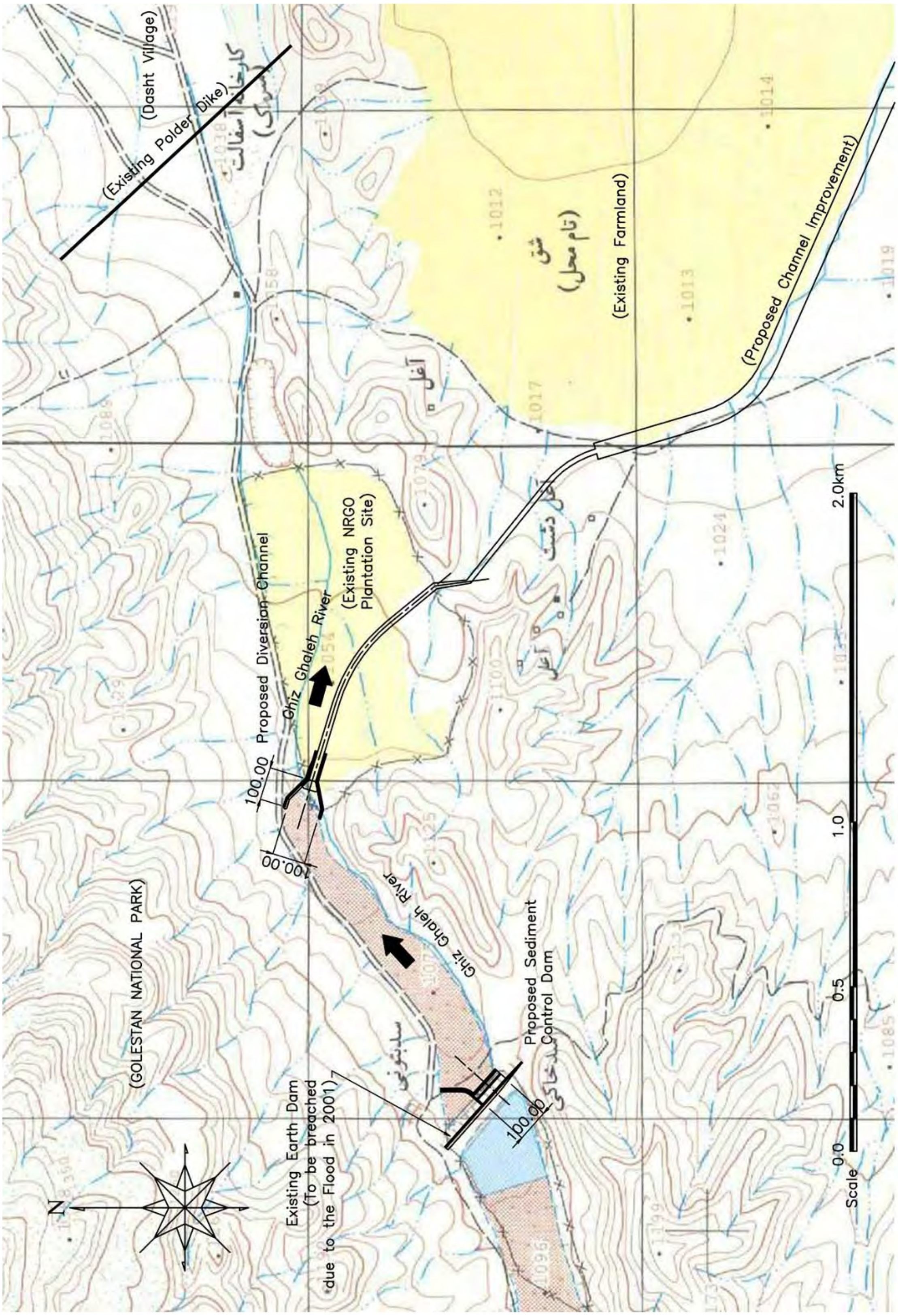

Fig. 3.17 Proposed Arrangement of Sediment Control Dam Facilities

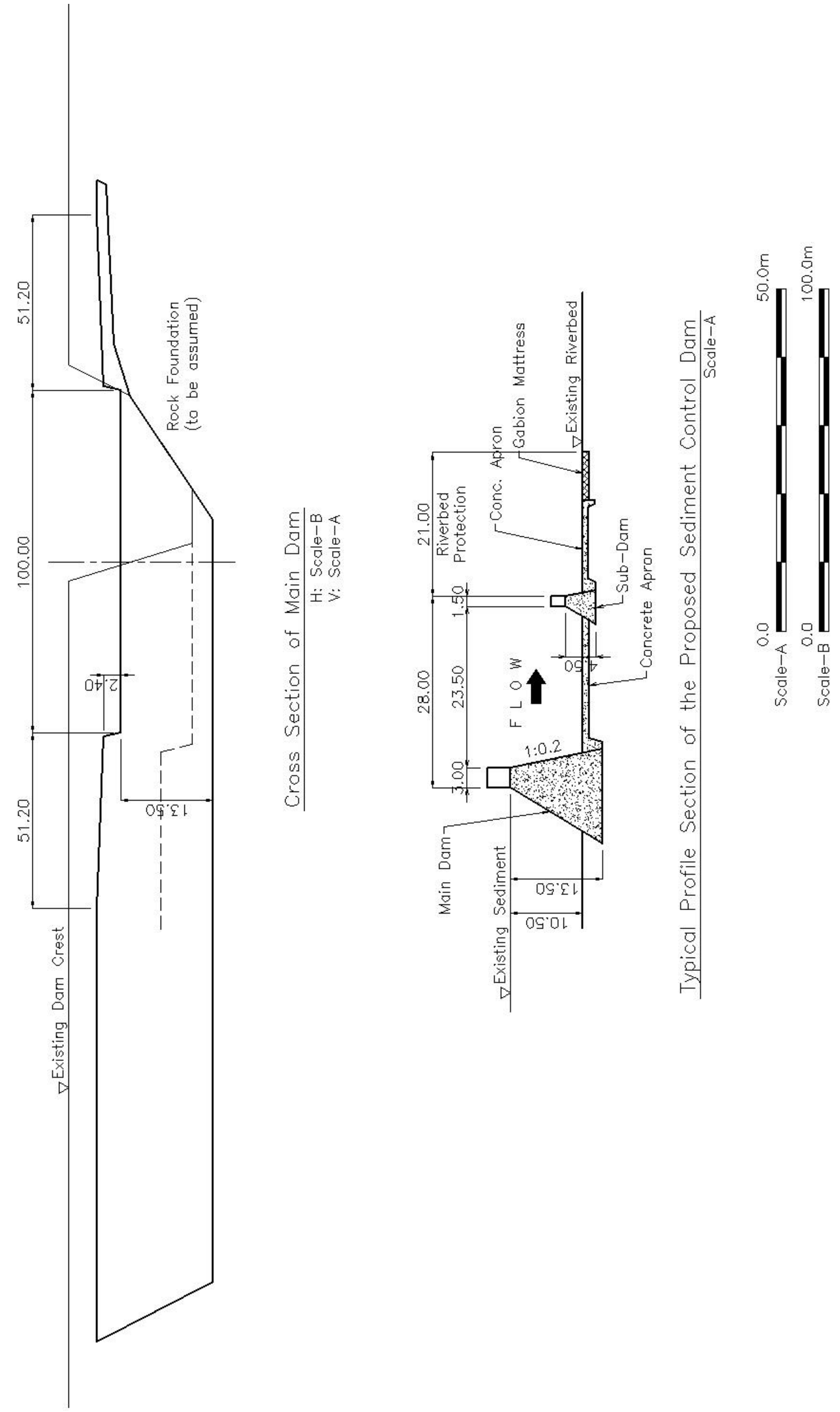

Fig. 3.18 Typical Section of Proposed Sediment Control Dam

3.3.3 Project Cost and Implementation Program

Project Components

The project is composed of the following structural measures:

- Gelman Darreh- Madarsoo River Channel Improvement (L= 6.6km stretch)
- Dasht-e-Sheikh River Channel Improvement (L= 5.1km stretch)
- Ghiz Galeh River Channel Improvement

Ghiz Galeh River channel improvement is consisted of the diversion channel (L= 1.0km) and sediment control dam.

Project Cost

The costs of the proposed projects/measures are to be estimated based on the following conditions.

(1) Price Level and Exchange Rate

The cost is estimated based on August 2005 constant prices in Rials. The exchange rates to be applied are:

USD 1 = 8,996 Rials and JPY 100 = 8,025 Rials (as of August 1, 2005)

The value added tax (VAT) for all cost components and import tax for imported equipment are to be included in each unit cost.

(2) Project Cost Components

The project cost is composed of the following items:

a) Construction Cost

b) Land Acquisition Cost

c) Compensation Cost

d) Administration Cost

e) Engineering Cost

f) Physical Contingency

The above contents are described as follows:

(3) Construction Cost

The construction cost is basically estimated by unit price basis, which multiply the work quantity by the unit price. The Study and Evaluation Department, Watershed Management Office, Ministry of Jihard-e-Agriculture provides the each unit price. In addition, basic price lists in 2004 prepared by Management and Planning Organization can be referred.

(4) Land Acquisition and Compensation Cost

The cost estimate for the land acquisition and compensation is based on the cost data obtained from the MOJA-Golestan Office. The land acquisition cost depends on the individual area in the Madarsoo River basin. The following table shows the land acquisition cost for the individual area in the Madarsoo River basin.

Table 3.17 Land Acquisition Cost in the Madarsoo River Basin

Unit: Rials/m^2

Land Use \ Location	Golestan Dam to Tangrah	Dasht
Dry Farming Land	4,000	400
Irrigated Farmland	6,000 to 8,000	3,500 to 5,000
Orchard	10,000 to 15,000	10,000 to 12,000
Residential Area	50,000 to 150,000	20,000 to 150,000

Source: JICA Study Team

(5) Administration and Engineering Cost

Administration cost and engineering cost to be required for the project implementation are estimated by lump-sum basis, which is assumed at 5 % of the construction cost for the government administration, at 10 % of the construction cost for the detail design and the construction supervision as the engineering service cost, which are based on the similar projects have undertaken by JICA; namely, The Study on Watershed Management Plan for Karoon River (2002) and The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland (2005).

(6) Physical Contingency

The physical contingency, which is based on the said similar projects, is provided with 20 % of the sum of the construction cost, land acquisition cost, compensation cost, administration cost and engineering cost.

The construction cost for the river restoration plan based on the above conditions is estimated at 253.2 billion Rials (in accordance with 28.2 million US$). The summary of the project cost for the channel improvement of Gelman Darreh- Dasht-e-Sheikh Rivers and Ghiz Ghaleh River is shown as follows:

Table 3.18(1) Summary of the Project Cost Estimate (Gelman Darreh- Dasht-e-Sheikh River)

Work Item	Quantity	Unit	Amount (1,000 Rials)
I. Construction Base Cost			**138,453,000**
1. Preparatory Works	1	l.s.	12,587,000
2. Channel Works	1	l.s.	125,866,000
II. Land Acquisition Cost			**3,442,000**
III. Administration Cost (5% of Item I)	1	l.s.	**6,923,000**
IV. Engineering Cost (10% of Item I)	1	l.s.	**13,846,000**
V. Physical Contingency (20% of Item I + II + III + IV)	1	l.s.	**32,533,000**
VI. Total			195,197,000
Round Total			**195,200,000**
in accordance with (as of August 2005)			US$21,699,000

Table 3.18(2) Summary of the Project Cost Estimate
(Ghiz Ghaleh River)

Work Item	Quantity	Unit	Amount (1,000 Rials)
I. Construction Base Cost			**40,500,000**
1. Preparation Works	1	l.s.	3,682,000
2. Diversion Channel Works	1	l.s.	20,170,000
3. Sediment Control Dam Works	1	l.s.	16,648,000
II. Land Acquisition Cost			**0**
III. Administration Cost (5% of Item I)	1	l.s.	**2,025,000**
IV. Engineering Cost (10% of Item I)	1	l.s.	**4,050,000**
V. Physical Contingency (20% of Item I + II + III + IV)	1	l.s.	**9,315,000**
VI. Total			55,890,000
Round Total			**55,890,000**
in accordance with (as of August 2005)			US$6,213,000

Implementation Program

Formulation of implementation program shall be considered present situations in the Dasht area. There is a breached earth dam exists upstream of the village along the Ghiz Galeh River, while there are no clear river channel along the three rivers. Furthermore the breached earth dam stored an enormous volume of sediment in its upstream basin. If large-scale floods occur, erode stored sediment, and transport it towards the Dasht village, the village had to suffer not only floodwater inundation but also sediment deposits in the town area simultaneously. Thus the existing breached dam and stored sediment could be the most serious disaster-causing factor to the village.

In this context, the first priority should be given to construction of sediment control dam in the Ghiz Galeh River. Following this project, river improvement in three rivers should be conducted continuously. Considering the sequence of the works and their realistic work volume, the following implementation program could be proposed.

Table 3.19 Implementation Program of River Restoration and Improvement Plan

Year	Sediment Control Dams	River Improvement
1st	Detailed Design	
2nd	Construction (4 years)	
3rd		
4th		
5th		Detailed Design
6th		Construction (5 years)
7th		
8th		
9th		
10th		

3.4 Golestan Forest Park Disaster Management Plan

3.4.1 Issues to be Addressed

In the 2001 Flood, around 200 visitors and campers died in the park. Most of the camping sites are situated on the previous debris flow deposits due to flat topography, and usually campers and visitors enjoy its natural environment extending over 15 km along the riverbank. In the 2001 flood, debris flow occurred in the six mountain streams in the park. Debris flow in five streams out of six attacked the camping sites. Furthermore extremely large floodflow coming from the upper stretch simultaneously swept away visitors and campers as well as natural forest alongside of the Madarsoo River course in the park. Thus the Golestan Forest Park area is the most disastrous part in the Madarsoo River basin as demonstrated in the 2001 Flood.

Recently the large-scale flood attacked the Golestan Forest Park again on 10 August 2005. Beforehand MET-Golestan announced flood warning as their weather forecast on 8 August, and Traffic Police shut off the connection road and drove visitors out of the Park in the afternoon on 9 August. As a result these activities achieved no casualties being affected by the 2005 Flood in the Golestan Forest Park.

Issues on the total flood forecasting and warning system could be broadly categorized into three items through carefully reviewing the activities during the 2005 Flood and the existing hydro-meteorological monitoring system.

(1) Improvement on Meteo-Hydrological Data Collection System

Existing meteo-hydrological data monitoring and collection system has various issues, if those systems are utilized for flood forecasting and warning system in the Madarsoo River basin. These are:

- MET-Golestan collects past 1-, 3-, 6- and 24-hour data for weather forecasting purpose in the normal time. Once rain starts, MET will connect only two stations through their online network to obtain real time data at the same time. It is not automatic real time observation system.
- MOE collects past 2-hour data for meteo-hydrological data collection purpose. The flood forecasting and warning system requires to monitor real time rainfall and water level data at least 1 hour interval. This system is also not automatic real time observation system.
- The data transmission network using public telephone line has not high reliability. It is easily disconnected during heavy storms and floods.
- There are two water level monitoring sites in the basin; Tangrah and Dasht bridge. Those stations are located at the entrance of the Golestan Forest Park and upstream end of the Park along the Madarsoo River. Monitoring data at those two stations cannot be utilized for flood forecasting and warning to protect visitors and campers in the Park since there is no lead-time gaining for warning and evacuation activities. Thus another stations shall be installed in the upper part so as to gain the lead-time for the emergency activities.

(2) Establishment of Responsible Organization for Flood Forecasting and Warning

There is no data exchange between MET and MOE. Furthermore there is no responsible organization to integrate meteo-hydrological data, to analyze those data, to determine an announcement of flood warning, and to strongly support the decision making by the Provincial Disaster Management Committee (PDMC). Such responsible organization is necessary as a Center of Flood Forecasting and Warning System.

(3) Improvement of Smooth and Efficient Emergency Activities for Evacuation

So far weather bulletin issued by MET is only a basis for initial action of emergency activities against flood disaster. The weather bulletin gives global weather information and no precise rainfall data. As a result, hitting ratio of the forecast is rather low. If the ratio is too low, people concerning will not believe the official information, and preparation activities for floods may be considered loss of budget.

In the 2005 Flood, it was proven that emergency activities to evacuate people from the Golestan Forest Park area were very effective and mounted. It might be great learning effects from the disastrous 2001 Flood. Therefore improving hitting ration of the forecast shall be a succeeding target to create the safer region against the flood disaster.

3.4.2 Disaster Management Plan

<u>Flood Forecasting and Warning Improvement Concept</u>

Regarding the existing flood information system as discussed in 2.13 Flood Monitoring and Warning System, MET shall continue to issue weather bulletin and flood notice. In addition, the Flood Forecasting and Warning System (FFWS) shall be established utilizing existing equipment and facilities as much as possible. MET will observe rainfall through existing and additional rain gauge station, and the data shall transfer to the FFWS center by digital telephone network. MOE will also observe own gauges through existing and additional rain gauges and water level stations.

The FFWS center shall be established at PDMC as requested in the Technical Committee Meeting in March 2006. The FFWS center will perform integrating data processing and data editing in a form of flood forecasting and warning information. The related agencies can access to FFWS Web server to obtain the latest flood information on graphic and table basis.

The PDMC is also responsible for announcing warning and evacuation order to concerning agencies as well as municipality within the Madarsoo River basin through the telephone or facsimile. Each municipality officers where flood-warning posts will be equipped are responsible to operate flood-warning equipment by manual operation. Warning for visitors and campers in the Golestan Forest National Park shall be made in the same manner of present flood-warning method that the police shall close the entrance of both sides of road and the patrol car shall call attention to the visitors and campers for evacuation to outside of the park. The concept of the total system is illustrated in Fig. 3.19.

At present in PDMC, there are no meteorologists and hydrologists to analyze meteo-hydrological data and to set the threshold level of rainfall and water level. Therefore, if the FFWS center is established in PDMC, reinforcement of human power is crucially necessary.

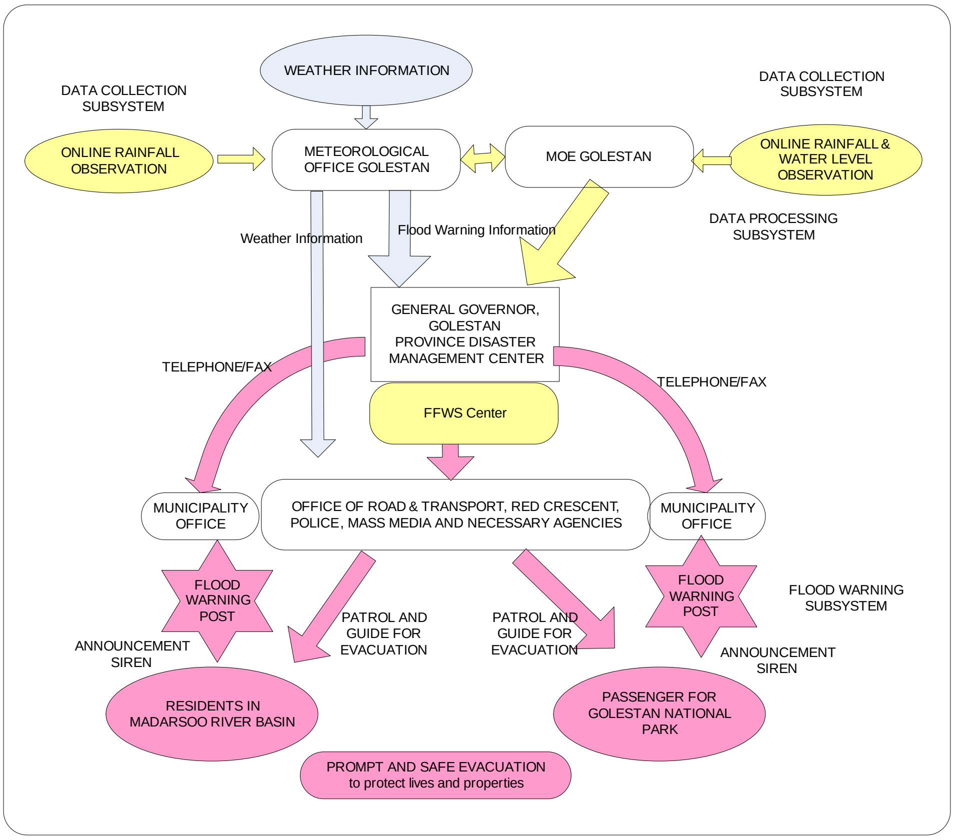

Fig. 3.19 Required Flood Information Flow

Improvement of Monitoring Network

As described in 3.1.7 Hydrological Setup, large floodwaters during floods come from the Gelman Darreh basin. In order to detect occurrence and imminent arrival of floods and to gain lead-time for emergency activities, additional online monitoring stations need installing in the upper basin. These are:

- Water level gauge: two water level gauges, Gelman Darreh along the Gelman Darreh River and proposed sediment control dam along the Ghyz Ghaleh River.
- Rain gauge: four rain gauges in the Gelman Darreh basin, Nardin, Soodaghlan, Haghaikhajeh, and Sefid Dally.

Proposed online meteo-hydrological monitoring network is illustrated in Fig. 3.20.

According to simulation results in the 2001 Flood, the peak discharge appears at Gelman Darreh station around 1 hour before appearance of peak discharge at Dasht Bridge. Furthermore if the threshold discharge was set up at 300 m^3/s at Gelman Darreh that is equivalent to around 20-year flood, the lead-time of around 2.5 hours at Dasht Bridge and around 4 hours at Tangrah can be gained for the emergency activities. These simulation results verify the effectiveness of additional gauge installation in the Gelman Darreh basin for early warning system. Fig. 3.21 shows the hydrological simulation results of the 2001 Flood.

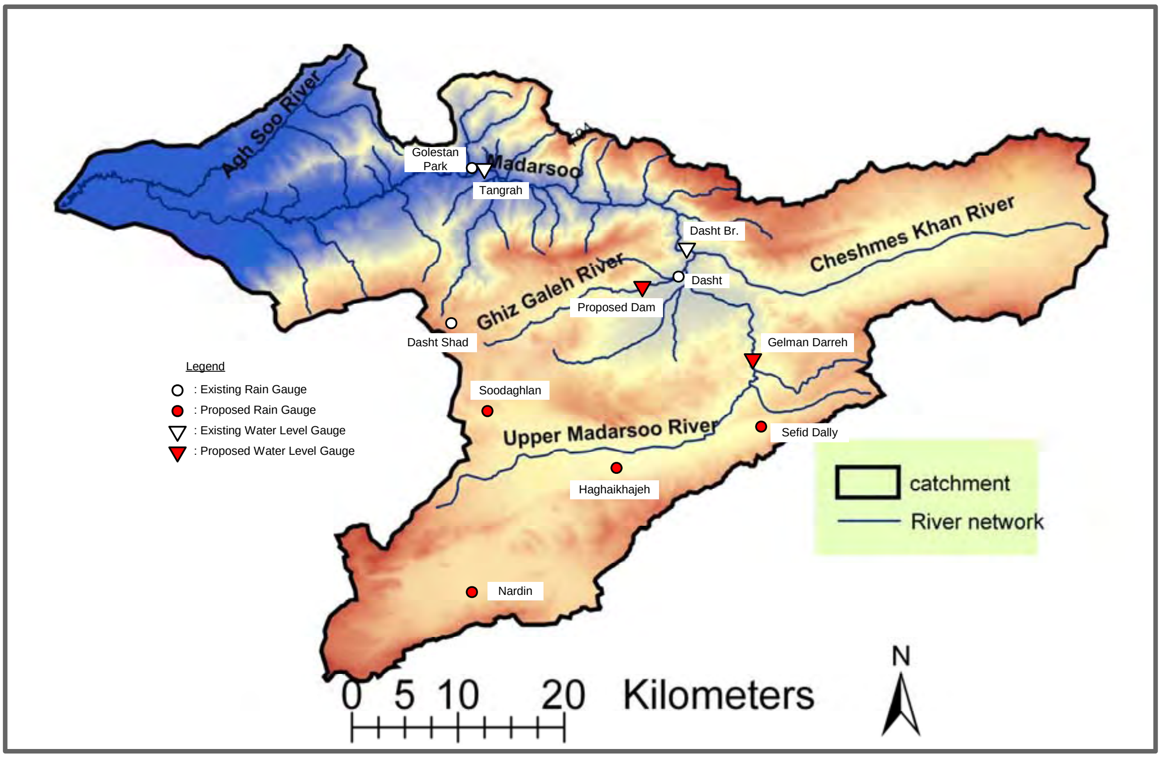

Fig. 3.20 Proposed Online Meteo-hydrological Monitoring Network

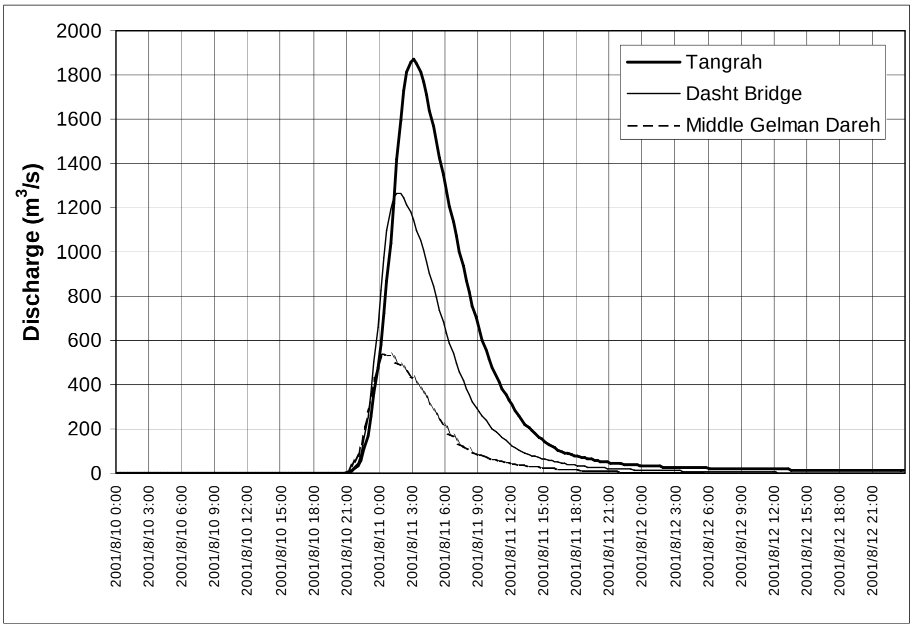

Fig. 3.21 Simulated Hydrograph of the 2001 Flood

<u>Improvement of Data Collection and Processing System</u>

The data collection subsystem uses the telemetry technology to collect data from remote points, and there are various link systems for data collection. The link systems available in Iran are (1) public telephone network, (2) GSM mobile phone system and (3) radio telemetry system. The GSM mobile phone system is most suitable for telemetry system. However, the traffic volume suddenly increases during and immediately after disasters, so that telephone connections become very difficult. On the other hand, the radio telemetry system is quite reliable from the general viewpoint. It can secure highly reliable and real-time communications even in disasters. However, the initial investment cost is significant high.

Also, this radio network has a trouble of an application for frequency license and complicated network design including setup of repeater station is required.

The comparison is shown in Table 3.20. In due consideration of applicability and easy modification of the existing data collection system, GSM mobile telephone network with MODEM could be considered the most applicable and easiest way to improve the existing system.

Table 3.20 Summary of Network Comparison

Transmission Method	Advantage	Disadvantage
Dial-up Telephone Line	□ Easy installation by user side □ No own maintenance work	□ Low transmission speed □ Taking long time for restoration in trouble □ Monthly payment of due for subscription.
Dedicated Exclusive Telephone Line	□ Continuous obtaining online data from the observation station □ High line quality and reliability	□ Higher telephone subscription □ Taking long time for restoration in trouble
GSM MODEM	□ Easy installation by user side. □ No own maintenance work	□ Working within GSM service coverage □ Monthly payment of due for subscription □ No connection during traffic congestion time such as floods
VHF/UHF Radio Link	□ Continuous obtaining online data from the observation station □ Stable and reliable data transmission □ No communication charge	□ Complicated process for frequency application □ High installation cost including repeater station □ Necessity of own maintenance work

GSM mobile network data collection system has several kinds of transmission method. GSM DATA will employ to cope with long data transmission by Climatologic station.

(1) Short Message Service (SMS)

The service will give short message transmission within 160 characters that is enough capacity for rainfall and water level data transmission. Data collection PC can call the observation station by polling mode and the observation station can activate data collection PC by event reporting method if the observation station has such alarm detective function. PSTN MODEM can be used between data collection station and exchange

(2) Circuit Switched Data (GSM DATA)

Maximum 9,600 bps data transmission can be possible by this method. This method is suitable for polling call system.

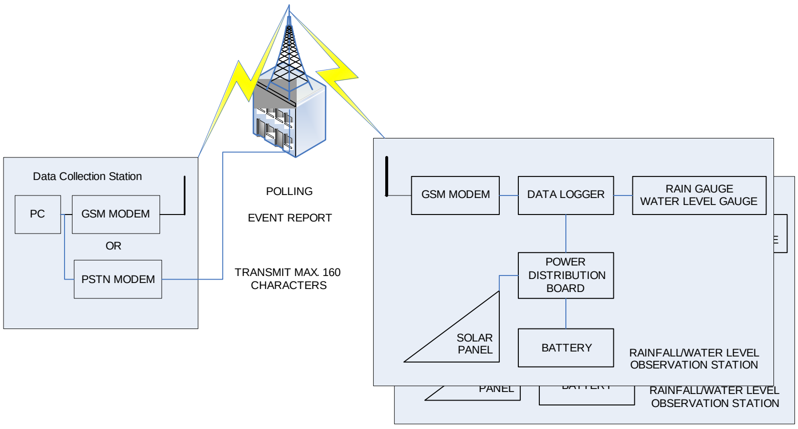

Fig. 3.22 Concept of GSM-GSM Network

Regarding data processing and transmission system, the system will use existing data processing software to add some improvement. For the data transmission system that is feasible in Iran, the digital telephone network such as ISDN and ADSL are available. The telephone network has disadvantages that it is inferior in reliability because it may be damaged and cause link disconnections due to traffic congestion in the flood time. In considering present situation and cost, ADSL or ISDN line will be used for the connection among the related offices, PDMC-FFWSC, MET, MOE and so on. Layout plan of Data processing and monitoring system is presented in the following figure.

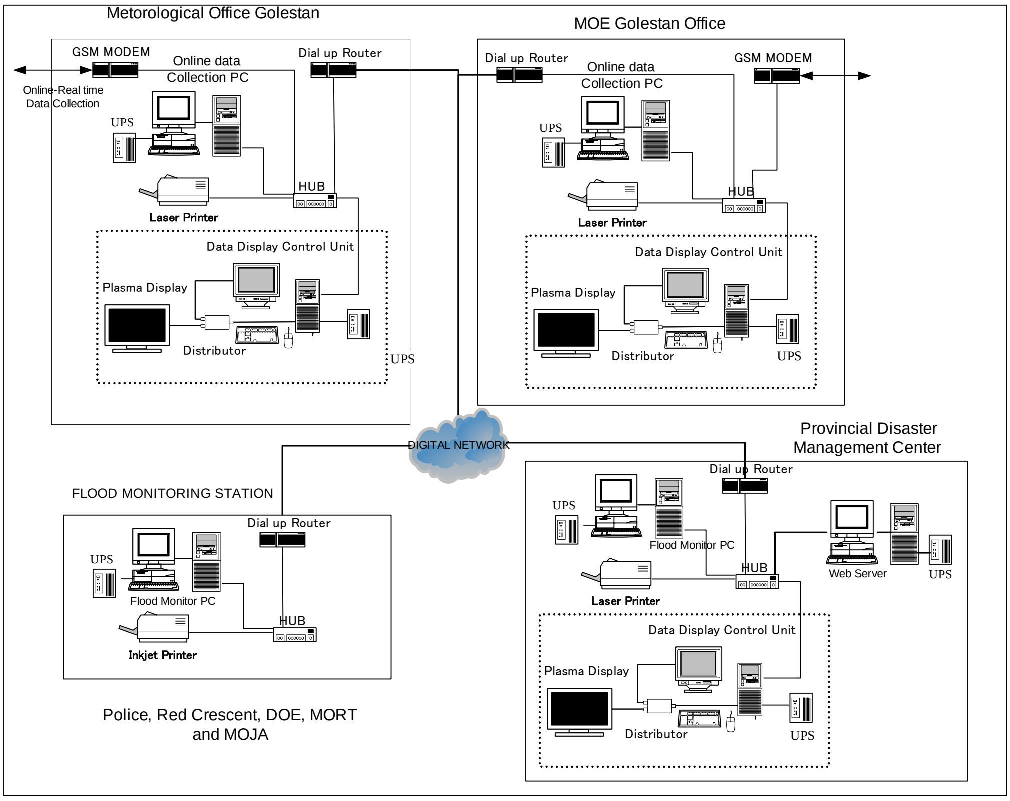

Fig. 3.23 Layout Plan of Data Processing and Transmission Network

<u>Improvement of Data Dissemination and Warning System</u>

The flood forecasting system will give early flood warning information. The related agencies take necessary actions based on such information. After that, information dissemination system (warning post) to inform flood warning and evacuation order should be necessary for inhabitants who live and work within the Madarsoo river basin. The warning posts will be installed in each village where the flooding water affects along the Madarsoo River. The warning post will also use for public information broadcasting during normal period.

The following table lists up entire villages in the basin not only for the purpose of Golestan Forest Park Disaster Management but also for Flood Preparedness in the entire basin as described in 3.8. The following 26 warning posts are planed to disseminate warning information to particular area. Planned warning post will be installed from Ghazal Police station where is entrance of the Golestan Forest National Park from the east side, to the rivermouth at the Golestan Dam. Necessity numbers of warning post will be discussed with concerning agencies and village residents. The warning post will be installed at the village office or house of the village master.

Table 3.21 Flood Warning Post Installation Sites

No.	Station	Place	Connection Line	Responsible Person for Operation
WP-1	Dasht	Mosque compound	Public telephone line	Village chief
WP-2	Ghazal Police	Ghazal Police station	MORT Radio network	Chief of police station
WP-3	Tangeh Gol	DOE office	DOE Radio network	Staff of DOE office
WP-4	Tangrah	National Park Office	Public telephone line	Staff of National Park Office
WP-5	Terjenly	Center of village	Public telephone line	Village chief
WP-6	San Jangal	Center of village	Public telephone line	Village chief
WP-7	Besh Oily	Center of village	Public telephone line	Village chief
WP-8	Google Bozorg	Center of village	Public telephone line	Village chief
WP-9	Google Kochak	Center of village	Public telephone line	Village chief
WP-10	Sadegh Abad	Center of village	Public telephone line	Village chief
WP-11	Loveh	Center of village	Public telephone line	Village chief
WP-12	Agh Ghamish	Center of village	Public telephone line	Village chief
WP-13	Koran Kaftar	Center of village	Public telephone line	Village chief
WP-14	14 M Bridge	Center of village	Public telephone line	Village chief
WP-15	Ganjig Shahrak	Center of village	Public telephone line	Village chief
WP-16	Amam Jafar	Center of village	Public telephone line	Village chief
WP-17	Abn Shir Mely	Center of village	Public telephone line	Village chief
WP-18	Ajen Ghareh Khojeh	Center of village	Public telephone line	Village chief
WP-19	Chaghar Shirmely	Center of village	Public telephone line	Village chief
WP-20	Gharavol	Center of village	Public telephone line	Village chief
WP-21	Kose	Center of village	Public telephone line	Village chief
WP-22	Ghilanshah	Center of village	Public telephone line	Village chief
WP-23	Gink Lic	Center of village	Public telephone line	Village chief
WP-24	Ghakh Ghand	Center of village	Public telephone line	Village chief
WP-25	Khojeh Lor	Center of village	Public telephone line	Village chief
WP-26	Gharkar	Center of village	Public telephone line	Village chief

3.4.3 Implementation Program and Project Cost

The proposed flood forecasting and warning system consist of (1) improvement of monitoring network, (2) improvement of data collection system, (3) improvement of data processing and transmission system including establishment of FFWS Center, and (4) Installation of data dissemination system, as described in 3.4.2.

Establishment of flood forecasting and warning system shall proceed following step-wise plan as summarized below.

Table 3.22 Implementation Program of Flood Forecasting and Warning System

No.	Work Item	Necessary Period (year)	Remarks
1.	Improvement of monitoring system	1	4 rain and 2 water level gauges
2.	Improvement of data collection system	1	
3.	Improvement of data processing and transmission system	2	including establishment of FFWS Center
4.	Installation of data dissemination and warning system	1	24 warning posts (excluding Dasht and Terjenly villages)

In accordance with the above implementation program, project cost is estimated as tabulated below. The following table shows overall flood forecasting and warning system in the Madarsoo River basin including installation of warning posts in the middle and lower reaches.

Table 3.23 Project Cost for Overall Flood Forecasting and Warning System

Work Item	Amount (1,000 Rials)
1. Improvement of monitoring system	994,600
-1 Furnishing Works	420,000
-2 Others	574,600
2. Improvement of data collection, processing and transmission system	1,740,500
-1 Furnishing Works	735,000
-2 Others	1,005,500
3. Installation of data dissemination and warning system	3,836,200
-1 Flood Warning Post	1,620,000
-2 Others	2,216,200
Total	6,571,300
Round Total	6,600,000

Others include the costs for preparatory works, installation works, administration, engineering, physical contingency, and miscellaneous.

In addition, only concentrating to the Golestan Forest Park area, the necessary project cost could be summarized as follows. Number of warning posts and their cost are reduced.

Table 3.24 Project Cost for Golestan National Park Flood Forecasting and Warning System

Work Item	Amount (1,000 Rials)
1. Improvement of monitoring system	994,600
-1 Furnishing Works	420,000
-2 Others	574,600
2. Improvement of data collection, processing and transmission system	1,740,500
-1 Furnishing Works	735,000
-2 Others	1,005,500
3. Installation of data dissemination and warning system	479,500
-1 Flood Warning Post (3 places)	202,500
-2 Others	277,000
Total	3,214,600
Round Total	3,300,000

Others include the costs for preparatory works, installation works, administration, engineering, physical contingency, and miscellaneous.