SUPPORTING REPORT I (MASTER PLAN)

<u>PAPER IX</u>

Flood and Debris Flow Study

THE STUDY ON FLOOD AND DEBRIS FLOW IN THE CASPIAN COASTAL AREA FOCUSING ON THE FLOOD-HIT REGION IN GOLESTAN PROVINCE

SUPPORTING REPORT I (MASTER PLAN)

PAPER IX FLOOD AND DEBRIS FLOW STUDY

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CHAPTER 1 IN GENERAL

This part aimed to find potential hazard due to debris flow in the Madarsoo River Basin.

The study was carried out according to the procedure shown as follow

(1) Basic study: Through the study on geology and geography, and rainfall distribution to find characteristics on debris flow in this area.

(2) Select Target Basins:

(3) Formulate Inventory of Valleys

(4) Select Target Valleys

(5) Site Reconnaissance over the Target Valleys

(6) Formulate Countermeasure for the Target Valleys

Criteria to select target areas were described with two conditions as follows;

(1) To have potential hazard of flash flood or debris flow of the valley, and

(2) To have residential area, road and public property directly affected by flash flood or debris flow of the valley.

CHAPTER 2 BASIC STUDY AND TARGET AREA

2.1 Basic Study

The basic study was summarized as follows;

(1) Nardin Basin: Basically this basin was classified into semi-arid area, had no concentration of population at the valleys.

(2) Gelman Darreh Basin: This basin had no residential areas but caused to bring about floods to the Dasht Village.

(3) Daste-Sheikh Basin: This basin had no much concentration of population at the valleys.

(4) Ghyz Ghaleh Basin: This basin had much potential of debris flow and flood to the Dasht Village, which had suffered floods not only from this basin but also Daste-Sheikh and Gelman Darreh. Therefore, countermeasures in this area should be integrated those of these basins.

(5) Golestan Forest Basin: This basin had much potential of debris flow in the valleys as well as much potential of flash flood affecting road but no residential areas.

(6) Tangrah Basin: This basin had much potential of debris flow like that Terjenly, T4 valley, had produced debris flows disturbing human lives and traffic.

(7) Agh Soo Basin: This basin had no much sediment movement and concentration of population.

(8) Golestan Dam Reservoir Basin: This basin had so much flat land to cause no debris flow and flash flood.

2.2 Selection on Target Area

Three areas were selected as the target areas shown as follow;

(1) Tangrah Basin

(2) Golestan Forest Basin

(3) Ghyz Ghaleh Basin

2.3 Inventory of Valleys in the Target Areas

(1) Inventory was made coding the valleys as follows;

Table 2.1 Valleys with Codes in Tangrah and Golestan Forest Basins

Basin	Rule	Code Samples
Tangrah	Headed by T with number put at beginning with 01 in the right hand bank and with 101 in the left hand bank	T01, T02, --------- T101, T102, ------
Golestan Forest	Headed by F with number put at beginning with 01 in the right hand bank and with 101 in the left hand bank	F01, F02, ------------ F101, F102, ----------
Ghyz Galeh	Headed by G with number put at beginning with 01 in the right hand bank and with 101 in the left hand bank	G01, G02, ------------ F101, F102, -----------

Valleys with codes were shown as follows;

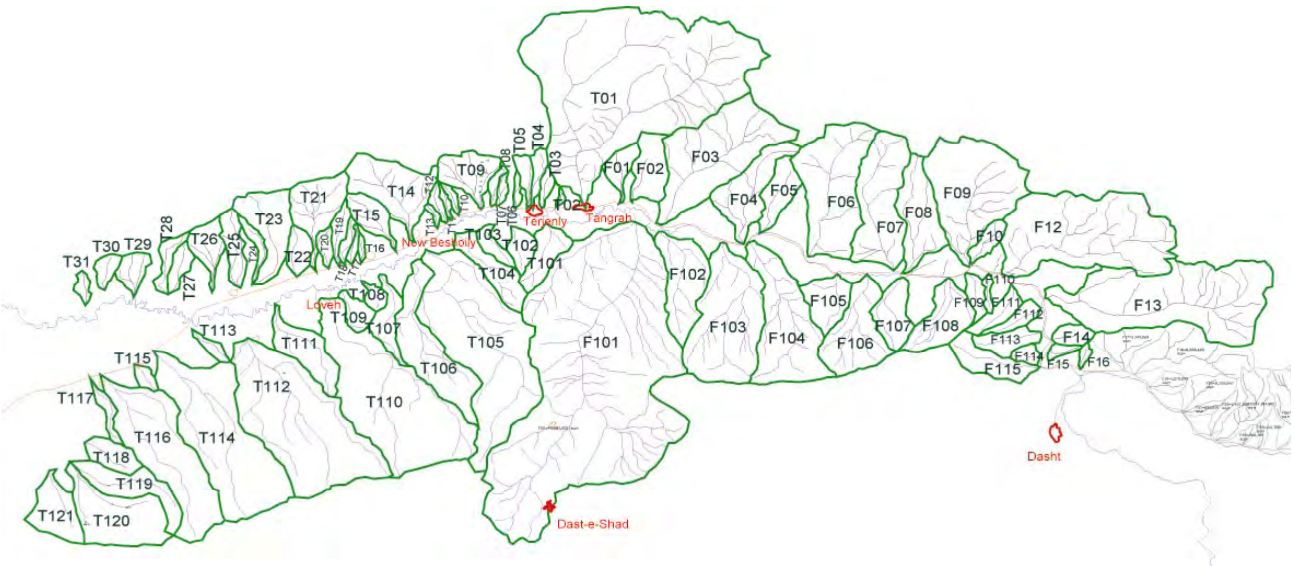


Figure 2.1 Valleys with Codes in Tangrah and Golestan Forest Basins

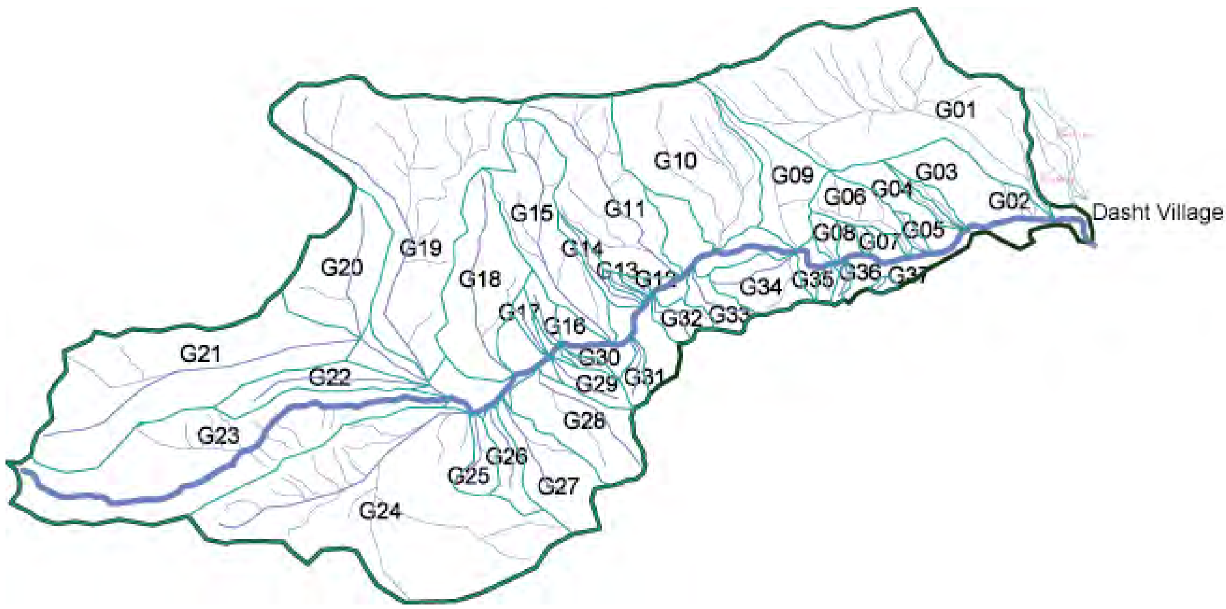


Figure 2.2 Valleys with Codes in Ghyz Galeh Basins

CHAPTER 3 SITE RECONNAISSANCE

3.1 Outline

Mechanism on how debris flow occurred was found through the observation over the project area and was described as follows;

1. Valleys in common had around 30 degrees in slope in upper part of the valleys while different degrees in slope in the valley mouths through 1 or 2 km; gentle and steep. Difference of the slopes in the valley mouth characterized the feature of the valleys.
2. There were three sections in the valley; sediment section, source section, and source production section.
3. Sediment section was defined as the section where debris flow spread and rested. In case the sediment section was located at residential land, road or other property, problems were serious. Source section was defined as the section where debris flow directly originated. Source production section was defined as the section where source of debris was produced like landslide area, gullies, and so on.
4. Source production section was mostly much wider in area and steeper in slope than the others. When collecting water in the section was concentrated enough to become flash flood at the source section, debris flow was occurred as a result that the debris was washed out to the downstream. In case the bed slope in the source section was very steep; commonly known as more than 15 degrees; debris flow was intensified reaching to considerable magnitude.
5. The source production section had been stable in respect of debris production because there were a few active movement like land slides and collapses. Therefore, the debris flows in this area had been derived mainly from the source section.

Schematic concept of such a mechanism was shown as follows;

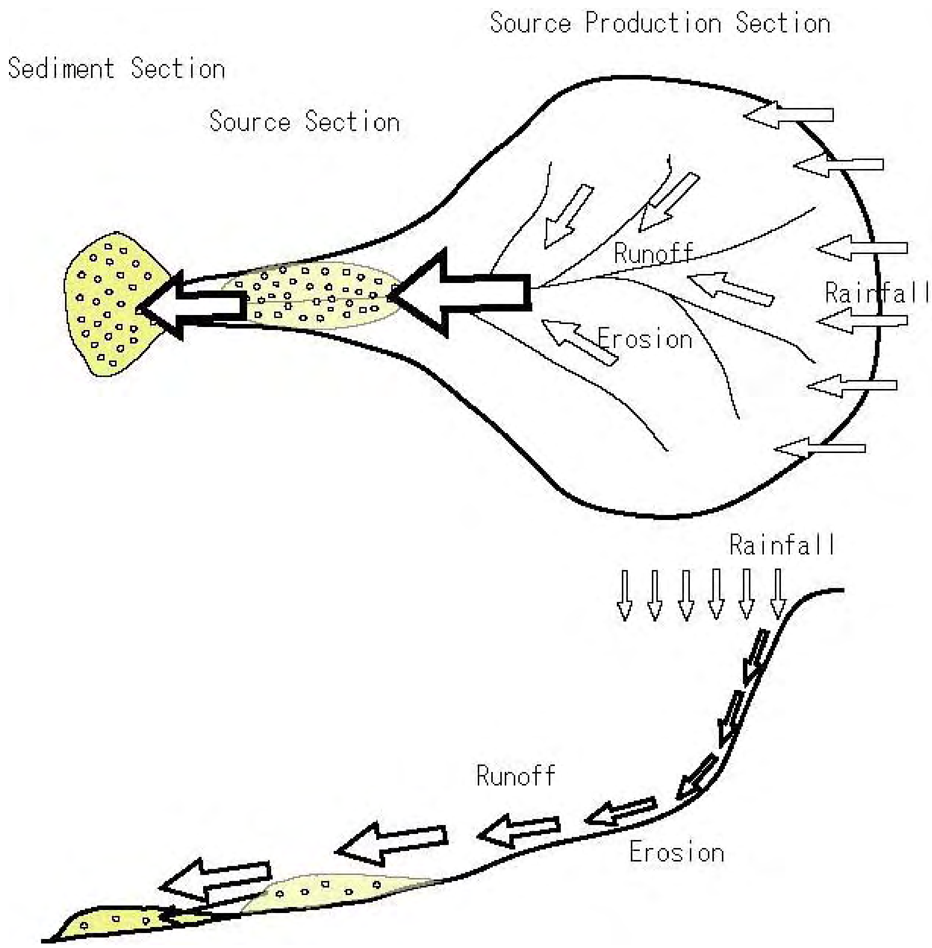


Figure 3.1 Schematic Concept of Debris Flow Mechanism in the Madarsoo

1. Considering such a mechanism of debris flow in the project area, Valleys were classified with differentia of slope in the valley mouth as follows;

   Type A: Less than 3 degrees

   Type B: Between 3 and 15 degrees

   Type C: More than 15 degrees

2. Overviewing debris condition in the study area, there were no considerable landsides or land-collapses in the source production section areas. Mostly debris flows in 2001-flood were occurred with debris transportation from the source section areas by flash floods into the sediment section and/or within the sediment section areas.

3.2 Inventory of Tangrah and Golestan Forest Basins

Inventory on debris flow potential of Tangrah and Golestan Basins was shown as follows;

Table 3.1 Inventory for Tangrah Area (Northern side)

Madarsoo River Debris Flow Inventory I

No.	Name	Area sq.km	Length km	Type	Events in 2001 Flood	Remark
1	T1	53.5	11.3	A	Flash Flood	
2	T2	0.2	0.8	B		
3	T3	0.7	1.4	B		
4	T4	1.1	2.7	B	3 killed in Terjenly village; Debris into road	
5	T5	1.1	2.0	B	Debris into road	
6	T6	0.4	1.1	B	None	
7	T7	0.5	1.4	B	None	
8	T8	0.7	1.9	B	None	
9	T9	4.1	2.9	B	Debris into road	MOJA plan
10	T10	0.5	1.5	B	None	
11	T11	0.4	1.4	B	None	
12	T12	0.7	1.9	B	None	
13	T13	0.3	1.2	B	None	
14	T14	7.6	4.4	A	Debris into road	MOJA plan
15	T15	2.7	3.4	A	None	
16	T16	0.3	1.0	A	None	
17	T17	0.5	1.8	B	None	
18	T18	0.7	2.3	A	None	
19	T19	1.3	2.7	A	None	
20	T20	0.9	2.2	A	None	
21	T21	5.4	4.6	A	None	
22	T22	1.9	2.4	A	None	
23	T23	5.9	5.1	A	None	
24	T24	1.1	2.9	A	None	
25	T25	2.5	3.8	A	None	
26	T26	2.7	2.6	A	None	
27	T27	1.5	2.5	A	None	
28	T28	1.5	3.3	A	None	
29	T29	1.8	2.1	A	None	
30	T30	1.2	1.7	B	None	
31	T31	0.7	1.5	B	None	

Table 3.2 Inventory for Tangrah Area (Southern side)

Madarsoo River Debris Flow Inventory II						
No.	Name	Area sq.km	Length km	Type	Events in 2001 Flood	Remark
1	T101	3.2	3.3	A	None	
2	T102	1.7	2.1	B	None	
3	T103	1.3	2.2	A	None	
4	T104	4.0	4.4	A	None	
5	T105	26.5	12.7	A	None	
6	T106	9.8	6.7	B	None	
7	T107	2.7	4.9	C	None	
8	T108	0.9	1.5	B	None	
9	T109	1.6	2.2	C	None	
10	T110	25.6	10.7	B	None	MOJA plan
11	T111	4.9	5.6	A	None	
12	T112	25.9	8.1	A	None	
13	T113	0.8	2.3	B	None	
14	T114	21.6	9.3	A	None	
15	T115	0.8	1.5	B	None	
16	T116	15.9	9.2	A	None	
17	T117	1.2	3.2	A	None	
18	T118	2.6	2.3	B	None	
19	T119	5.3	5.5	A	None	
20	T120	9.2	4.3	A	None	
21	T121	4.6	3.0	A	None	

Table 3.3 Inventory for Golestan Forest Area (Northern side)

Madarsoo River Debris Flow Inventory III						
No.	Name	Area sq.km	Length km	Type	Events in 2001 Flood	Remark
1	F1	1.9	2.5	B	Debris into Road	
2	F2	4.0	2.2	A	ditto	
3	F3	16.3	7.4	A	None	
4	F4	6.4	5.9	B	None	
5	F5	3.3	3.3	B	None	
6	F6	14.1	7.0	A	None	
7	F7	11.2	7.2	B	None	
8	F8	6.7	4.4	B	None	
9	F9	15.7	5.4	C	None	
10	F10	1.5	2.3	C	None	
11	F11	0.0	1.0	C	None	
12	F12	23.1	8.7	B	Fan formed in Rivercourse disturbed Flood Flow	
13	F13	24.6	10.5	B	None	
14	F14	1.4	1.0	C	None	
15	F15	0.6	1.5	B	None	
16	F16	0.4	1.0	C	None	

Table 3.4 Inventory for Golestan Forest Area (Southern side)

Madarsoo River Debris Flow Inventory IV						
No.	Name	Area sq.km	Length km	Type	Events in 2001 Flood	Remark
1	F101	75.6	16.6	A	Debris into the River disturbed Flood Flow	
2	F102	7.2	5.2	A		
3	F103	15.8	7.5	A		
4	F104	13.2	7.9	A	Debris into the Rivercourse disturbed Flood Flow	
5	F105	3.8	2.7	B		
6	F106	8.0	4.6	B		
7	F107	3.8	3.9	B		
8	F108	5.4	4.2	C	Fans formed in the Rivercourse disturbed the Flood Flow	
9	F109	1.3	2.0	C	ditto	
10	F110	0.5	1.6	C	ditto	
11	F111	1.9	2.7	C	ditto	
12	F112	1.5	2.3	B	ditto	
13	F113	2.4	2.9	B	ditto	
14	F114	0.9	1.2	C	ditto	
15	F115	3.8	4.0	B	ditto	

(3) Evaluation on Inventory Study

1. In Tangrah Basin, no valley was marked with C type or more than 15 degrees in slope at the valley mouth.
2. Villages of Tangrah (T1) and Terjenly (T4 and T5) were located as concentration of population in debris flow plains but other villages in the area were kept out of debris flow.
3. T4, T9 and T14 valleys had still high potential of debris flows spilling out to the road.
4. Golestan Forest Basin had valleys with C type, which was located upper side of the basin with relatively smaller basin areas and with fans projected into the Madarsoo before 2001-flood but not affected traffic.
5. Upstream parts of valleys mostly had more than 15 degrees in slope in both of the basins.
6. Valleys in the Ghyz Galeh had no population and traffic. The main stream had caused flood and debris flow to the Dasht Village.

CHAPTER 4 SPECIFIC VALLEYS

4.1 Golestan Forest Basin

Longitudinal cross-section of the Madarsoo from downstream of Dasht to Golestan Dam-Reservoir was shown as follows;

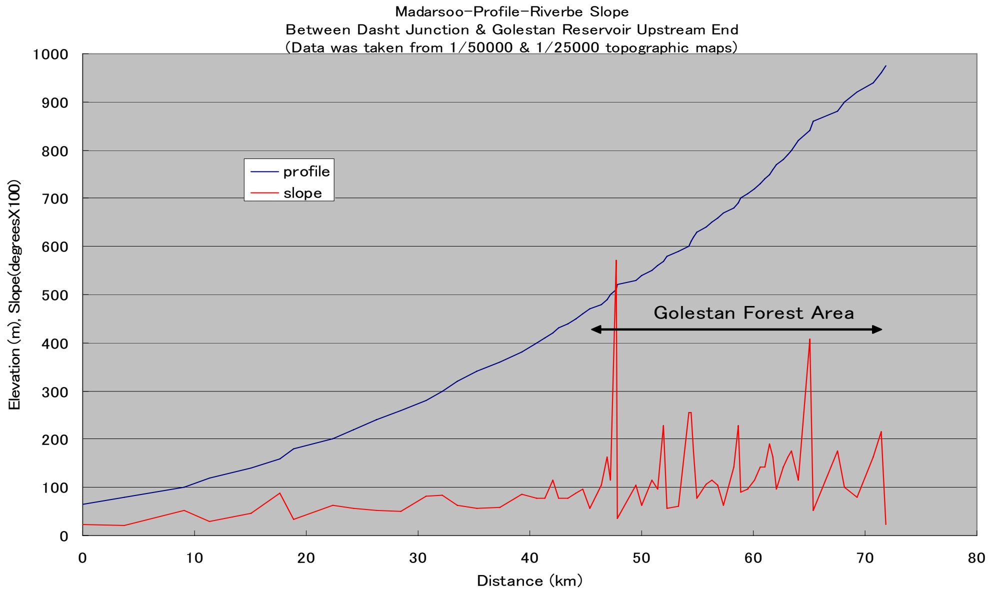


Figure 4.1 Longitudinal Profile of the Madarsoo

In the Golestan Forest Area, the riverbed was appeared repeatedly with slopes of around 1 degree and of more than that with 6 degrees in maximum, mostly less than 3 degrees. Downstream of Golestan Forest Area, the riverbed was appeared with slopes of less than 1 degree. Resulting site observation, the parts in the gentler slopes were located upstream of the narrow passages and the parts in the steeper slopes were located downstream of them.

According to the general study on debris flow, such mild slope does not cause debris flow so that such a movement of riverbed materials was caused by flood flow intensified in the narrow passages, natural or man-made, with clogging by debris with driftwood in 2001 flood.

After the 2001 flood, such driftwoods were mostly swept away so debris with driftwood was no longer the major cause of so-called debris flow hazard.

However, the narrow passages, natural like narrow valleys and man-made like roads and bridges, were still existed so that they still could intensify flood up to a destructive level and driving bank-erosion and debris-movement.

4.2 Tangrah Basin

4.2.1 T1 Valley (Tangrah Village)

(1) General Aspect

T1 flew through Tangrah Village crossing the national road and draining to the Madarsoo. The Eastern side of the basin belonged to the Golestan National Park. 2001 flood caused to destroy some houses and to flood in a school garden along the valley. There was a camping site for public use along the valley 2 km upstream from the road.

The section between the conjunction of the Madarsoo to 2 km point, where the camping site located, had streambed with around 2 degrees in slope. The upstream of this point to the 6 km point, where the two big tributaries shared the rest of the basin area with each other, had 3 to 4 degrees. The farther upstream area in this point had 5 to 10 degrees, gradually increasing to more than 15 degrees in parts of the upper section.

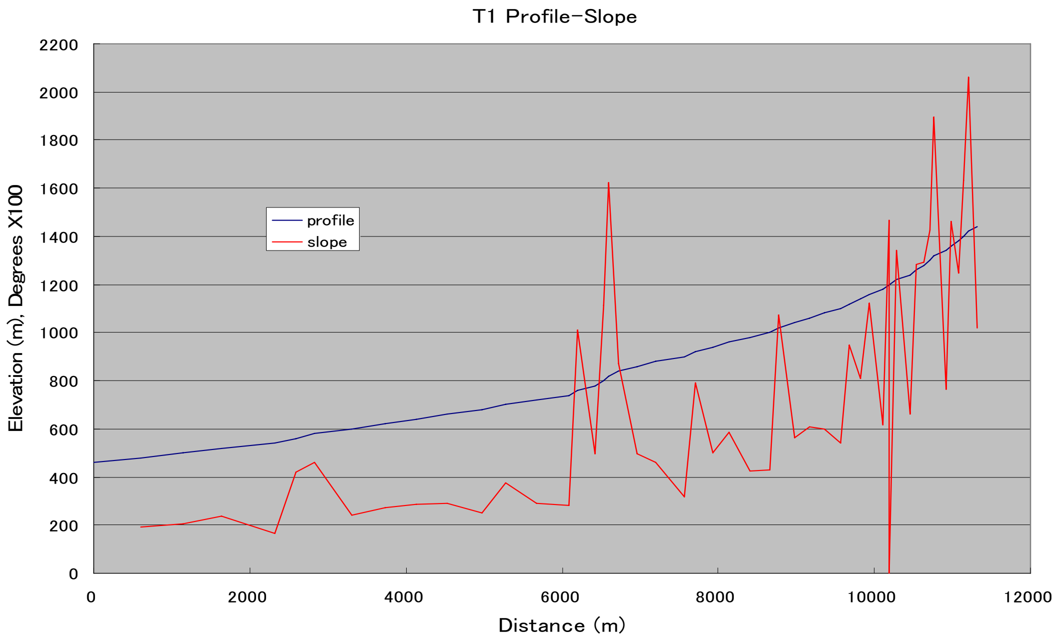


Figure 4.2 Longitudinal Profile of T1 Valley

(2) Sediment Section

There was not obvious trace of debris rested on the streambed but flash flood. The residents attested that the bridge section over the stream had no clogging by driftwoods during 2001-flood.

(3) Debris Sources Section

The gentle slope section from downstream end of the valley up to 6 km point had gravel layers with 1 to 3 meters in depth and small-scaled landslides at foots of some fans eroded by stream.

(4) Debris Production Section

The upper area from the 6 km point had relatively stable slope in the left hand side tributary while unstable in the right hand side.

(5) Evaluation

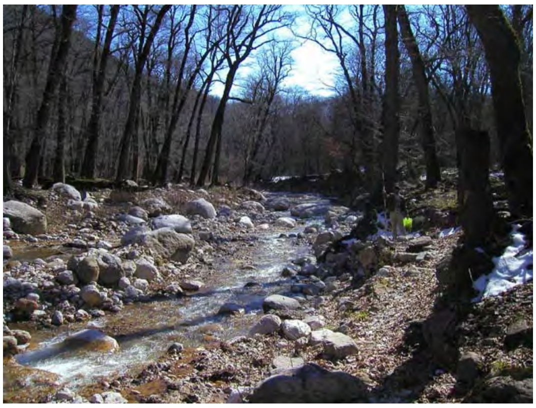
Considering the long and gentle slope of the streambed in the downstream and the wide catchment area and rainfall records in Tangrah, there were not much potential on debris flow but much potential on flash flood bringing serious damages to the areas along the valley.

Therefore, flood control facility shall be constructed to mitigate flood damages from the residents and public facilities.

(6) Required Countermeasure

Flood control facility was required to protect residence and public facility against flash flood while protection works against debris flow was not required.

Gravel layers in the downstream bed.



Erosion at foot of the fan.

Left hand side tributary

Right hand side tributary

Figure 4.3 Debris Condition of T1 Valley

4.2.2 T4 Valley (Terjenly Village)

(1) General Aspect

T4 Valley collected runoff in forest running though the Terjenly Village. The road, which divided the village into two, blocked the waterway while T5 Valley had.

Which was divided into two by the road, which blocked waterway while T5 Valley next to T4 Valley had a waterway crossing the road underneath a bridge.

Streambed in longitudinal section had 7 to 9 degrees in slop in the area from the road to 800 m upstream (800m section as the source section), more than 10 less than 30 degree from 800m to 1400m upstream (1400m section as the production section), and more than 30 degrees from 1400 m upstream (more than 1400m section). Part of the source section, the ground was scoured with 3 to 5 m in depth, 4 to 6 m in width forming a ditch forwarding to the downstream until the area of debris spread over the village.

Trace of the ditch suggested that debris flashed out to the village was originated from the ditch section while debris from further upstream area was not much appeared.

During 2001 flood, floodwater ran over the road to the southern side of the road spreading almost whole area of the village except some isolated portions.

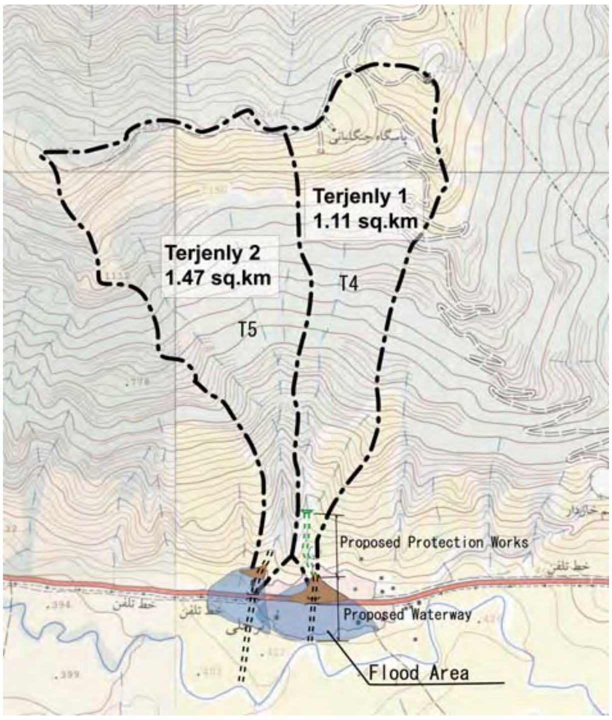


Figure 4.4 Plan of T4 & 5 Valleys

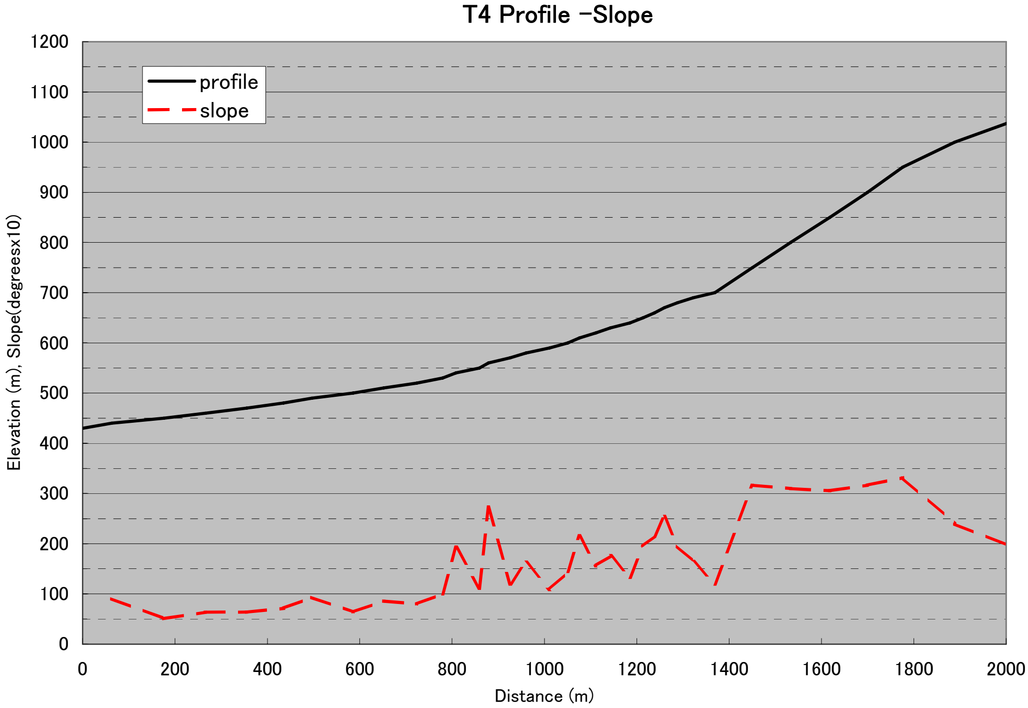


Figure 4.5 Longitudinal Profile of T4 Valley

(2) Sediment Section

At 2001 flood, T4 Valley produced debris flow washing away several houses in Terjenly and spreading over the road. A volume of the spread debris was estimated with around 10,000 cubic meters. The debris over the road was cleared for traffic security while some of it was still remained in the part of the Village. There was no waterway in this sediment section so flash flood should be blocked by debris rested in this section and spread the wider area over the village.

(3) Debris Source Section

In the right upper part of the sediment section was the ditch formed by scouring with 2 – 4 meters in width and around 300 meters in horizontal length. Washed out soil volume was estimated with around 8,000 cubic meters.

The upper end of the ditch had a mass of debris deposit, volume of which was estimated with around 3,000 cubic meters.

(4) Debris Production Section

The upper part from the section above mentioned, over around elevation 500 meters to 700 meters, had gullies with steep banks in both sides, which had been eroded to produce source of debris supplying to the downstream but the no significant landslide and land-collapse observed. The farther upstream part, over around more than elevation 700 meters, had steep slopes, around 30 degrees, with stable limestone exposed.

(5) Evaluation

Debris rested in the right upstream of the road still had potential hazard that flash flood was diverted to residential area by blockage of debris deposition or caused debris flow splash up to the road.

Both sides of wall and bottom in the scoured ditch were very vulnerable to erosion during flash flood.

(6) Required Countermeasure

The countermeasures required for this valley were described as follows;

1. Clear the remaining of debris deposit from the Terjenly Village property.
2. Consolidate the mass of debris deposit at the upper end of the ditch to prevent recurrence of debris flow in this valley.
3. Provide the waterway crossing the road to drain floodwater directly to the Madarsoo.
4. The Team had been still studying design discharge for hydraulic structure taking account into the rainfall records after 2001-flood while MOJA Golestan had adopted 30 cu.m/sec for the Tangrah Basin, which was based on the records before the 2001-flood
5. Warning with forecasting debris flow occurrence was useful for the residents to evacuate from the hazard at the right time.

1. Sediment section; still debris remained

2. Source section; cleared by flood

3. Source section; still debris remained.

4. Source production section; rock exposed in stable condition.

Figure 4.6 Debris Condition in T4 Valley

(7) Public Hearing

The Team proposed and explained on necessity of floodway channel and erosion protection works and requirement for land acquisition.

The residents agreed the proposal and claimed repeatedly for implementation of the floodway construction as soon as possible. They discussed how to solve the problem of land acquisition. Some of them expressed that they considered the flood problem so seriously that they had been discussing on the total relocation of the village like Besholly.

4.2.3 T5-Valley

(1) General Aspect

T5-Valley was running in parallel with the T4-Valley but debris condition was significantly different: Less potential of debris flow recurrences because of different condition in the sections as described in the followings.

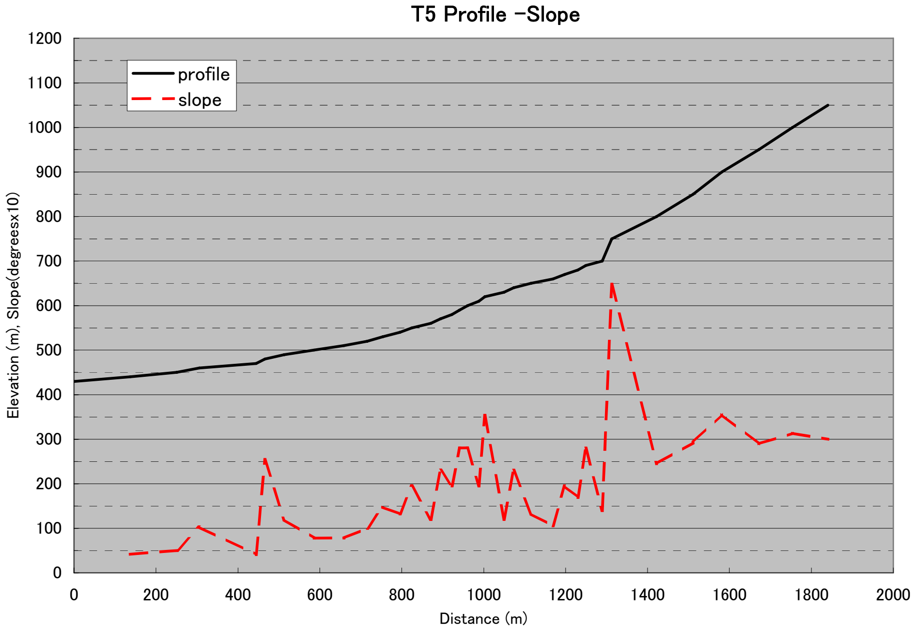


Figure 4.7 Longitudinal Profile of T5 Valley

(2) Sediment Section

The most of debris accumulated in the sediment section was cleared by excavation using restoration work of the Madarsoo after 2001 flood. A waterway was secured for the flash flow to drain to the Madarsoo without a blockade by a road unlike T4 Valley, its capacity was not enough to accommodate flood flow like 2001-flood.

(3) Source Section

The most of debris sources accumulated in the source section had been washed out to the downstream in the previous flash floods. Some of debris still was remained in several isolated portions.

(4) Source Production Section

The surface of the source production section was exposed with hard rock so that not much of source production for debris flow was observed in the section.

(5) Evaluation

There was not much potential on recurrence of debris flow if the present condition on debris in the source section and sediment section were maintained, but flash flood because of the flow capacity of the waterway was not enough for the requirement.

(6) Required Countermeasures

1. Improve waterway with bank protection.
2. Widen span of the bridge to secure enough flow capacity.
3. Clear the debris in the waterway and maintain it, especially in the sediment section and under part of the bridge in case the debris accumulated in the future.

4.2.4 T9-Valley

(1) General Aspect

T9-Valley had had debris flow, which was spilled out to the road, in 2001-flood. Source section still had debris accumulation, even though some parts of it were washed out in 2001-flood.

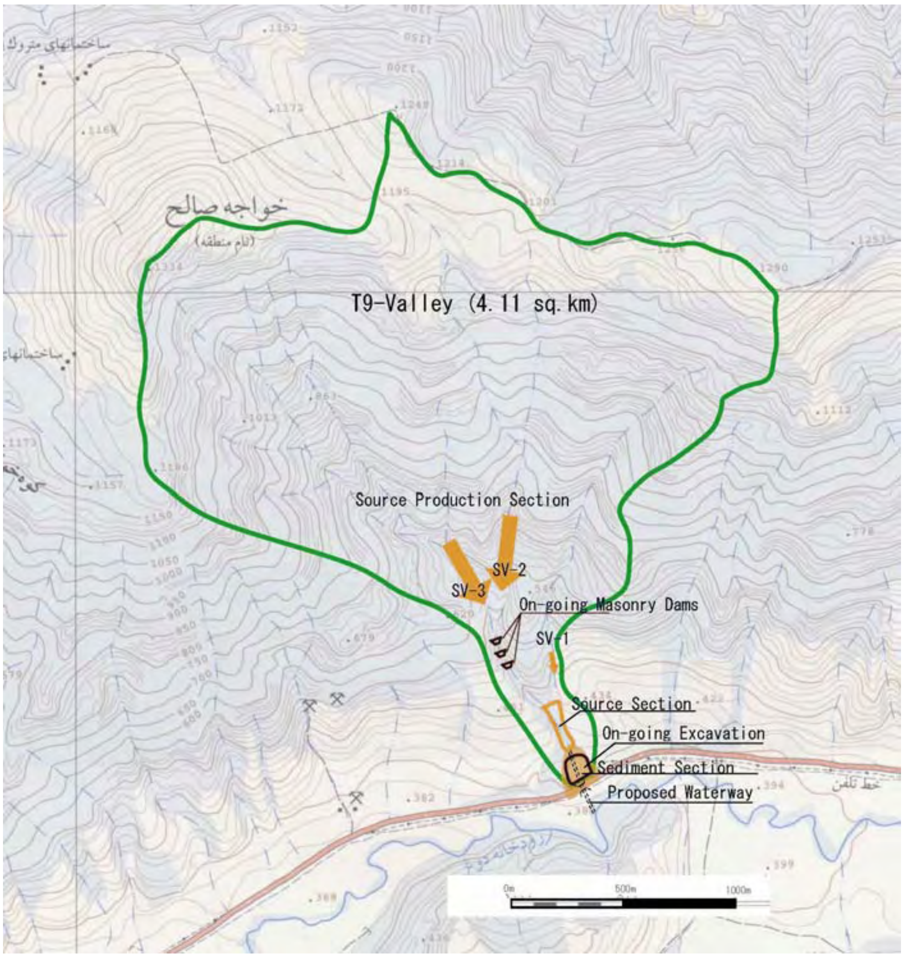


Figure 4.8 Plan of T9 Valley

(2) Sediment Section

In the sediment section, debris was still accumulated in some degrees enough to spill out to the road with the future flash floods that had been removed by excavation to use for construction material.

There was no waterway to release floodwater running through the sediment section and crossing the road and draining to the Madarsoo.

(3) Source Section

In the source section, still debris was remained with roughly estimated quantity of 12,000 cu.m. after the 2001-flood washed out some parts of it.

(4) Source Production Section

The source production section had much potential of debris supply source. Especially at the conjunction of SV-2 and 3 had unstable of debris accumulation, which was roughly estimated with 50,000 cu.m in volume.

Receiving debris from the upstream, series of masonry dams was under-construction.

(5) Evaluation

The future flash flood should gradually transport the debris from the sections of sediment and source to the downstream. Quantity of debris in the source section had reduced much than that before 2001-flood occurrence so that the magnitude of the future debris flow should be less than that in 2001-flood.

If the on-going excavation works continued to clear enough debris from the sediment section, safety in the immediate future for debris flow should be increased. In addition, if the three dams under-construction successfully completed, they should receive the debris transported from the source production section with their capacities.

Floodwater should spill over the road and nearest farmland whenever flash flood occurred because of no way-out to drain.

(6) Required Countermeasure

1. Maintain clearing the sediment section to provide a pocket for the future debris flashed out.
2. Monitor the debris condition. In case in future debris would spill out of the dams and reservoirs, additional dams and excavation should be required.
3. Provide waterway through the pocket area crossing the road with a bridge to drain floodwater to the Madarsoo.

T9-Valley; Sediment Section.

T9-Valley: Source Section

T9-Valley: Production Section

Figure 4.9 Debris Condition of T9 Valley

4.2.5 T14-Valley

(1) General Aspect

Valley T14 was located at the western side of the New Beshoily Village, divided into two streams running through the middle of fans formed in the valley’s outlet and passing underneath the two bridges. Debris was spread over the sediment section and spilled out nearby the road and farmland in 2001-Flood.

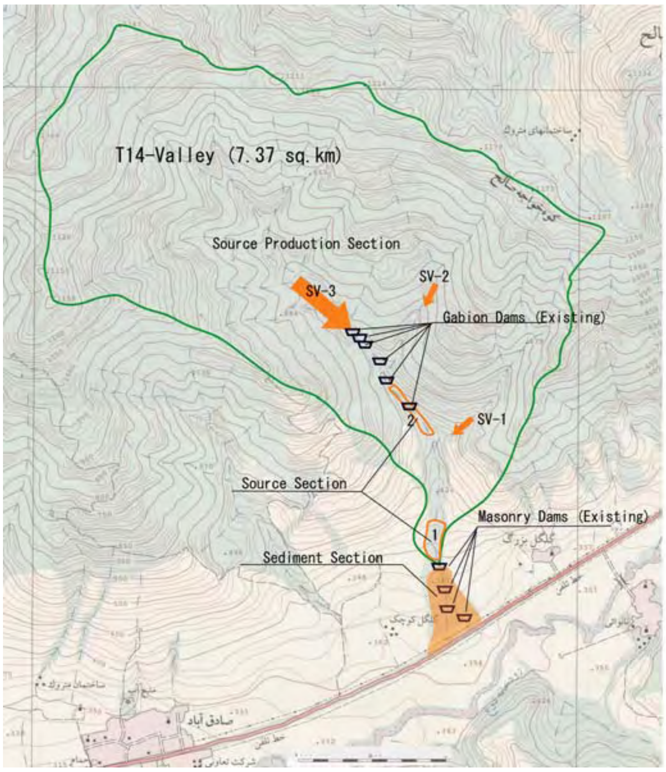


Figure 4.10 Plan of T14 Valley

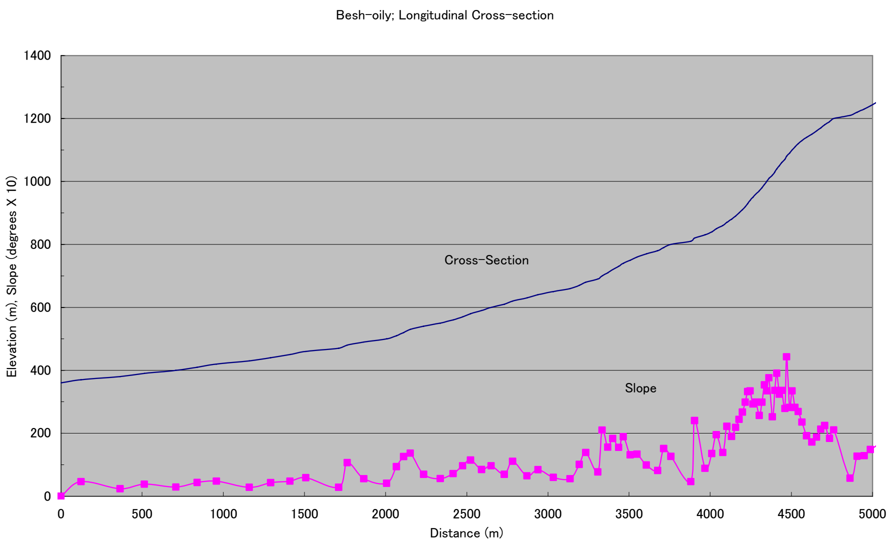


Figure 4.11 Longitudinal Profile of T14 Valley

(2) Sediment Sections

The debris spread over the road and nearby farmland in 2001-Flood.

The road ran through the middle of the sediment section blocking the flood flow, which was concentrated through bridges' spans causing to scour the downstream area.

One of two stream-channels was closed by the wing structure extended from the dam constructed in the other stream-channel.

The fan itself was relatively stable in debris condition along the stream banks and debris spread in 2001-flood was cleared already.

(3) Source Section

One of the major source sections was ranged in the immediate upstream of the first masonry dam; the other was in the section of series of gabion dams. Both of the sections had been eroded along the banks due to the stream meandering and vulnerability of the banks exposed with soil wall.

(4) Source Production Section

It was found through site observation on that SV-3 had considerably high productivity of the debris unlike SV-2 and 3 among several sub-valleys in the source production section. Six gabion-dams founded right downstream of SV-3 should function to receive the debris in their capacities.

(5) Evaluation

Most of debris in the source sections was washed out so how much of debris discharged in the future was depend on the vulnerability against bank erosion. There were six masonry dams constructed in the sediment section that should receive the debris and work to reduce the quantity to the downstream. It is difficult to estimate a quantity of eroded debris. Capacity of each dam was built in the narrow channel with a small pocket and elevation of its wing top was at the same level as the surrounding area or higher so allowance to contain flood water should be little and it might spill over to the surrounding area after the reservoir was fully filled by sediment.

In comparison on cross-section between the spillway of the existing dam and the stream, the former was relatively smaller than the latter.

(6) Required Countermeasures

1. Monitor bank erosion in the source section 1, and sedimentation in the dam reservoirs after the flash floods occurred.
2. Empty the debris accumulated in the dam reservoirs of the masonry dams after flash flood occurred in future.

 T14：Sediment Section	 T14：Source Section
 T14: Production Section	 T14: One of the masonry dams

Figure 4.12 Debris Condition of T14 Valley

4.3 Ghyz Galeh River Basin

(1) General Aspect

The 2001-flood brought debris flow to the farmland, spreading around 80,000 cubic meters in roughly estimated volume. During the time of the flood, toe at the fans, an earth dam and sediment of the reservoir were eroded. Those eroded sediments were roughly estimated with around 120,000 cubic meters.

Longitudinal cross section of the Ghyz Galeh Riverbed was shown as follows;

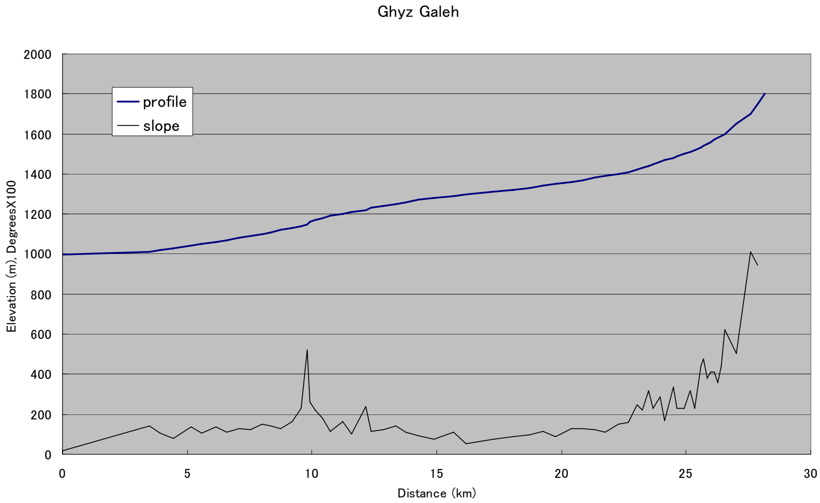


Figure 4.13 Longitudinal Profile of Ghyz Galeh

Slope less than 10 degrees covered the entire river range and almost less than 2 degrees did the range of 20 km from the downstream most.

Considering degree of slope in the range of this riverbed, debris flow unlikely happened without flash flood transported debris in some distance but never over kilometers.

Therefore, source of the debris spread over the Dasht farmland was considered to originate from the area between the broken dam reservoir and eroded portion of the fans.

After 2001-flood, MOE North Khoransan Province excavated debris to secure the waterway and embanked surrounding the village to protect from flooding.

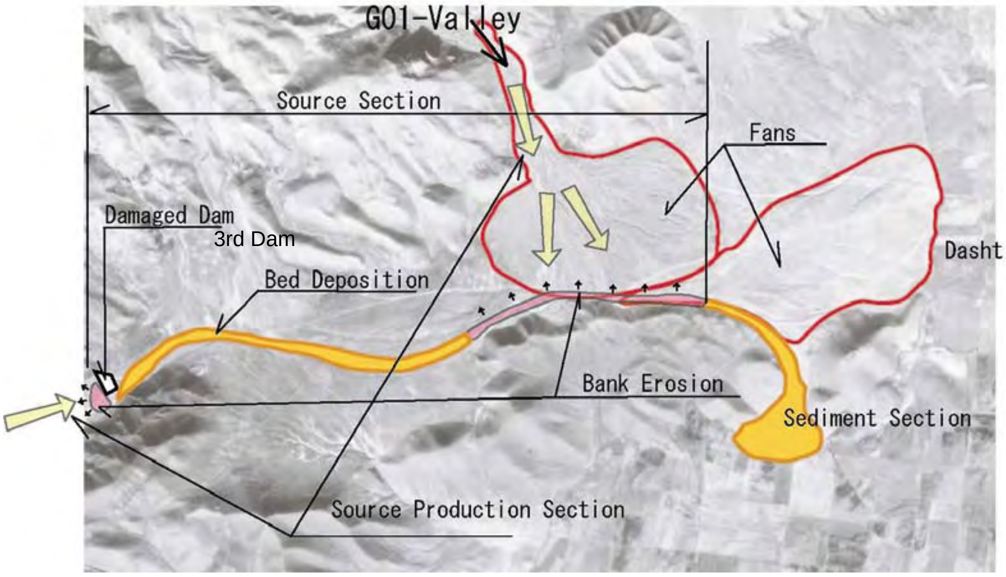


Figure 4.14 Schematic Concept of Debris Movement in Ghyz Galeh

(2) Sediment Section

Debris flashed out in 2001-flood were settled on the flat plain in stable condition against debris flow, which, after 2001-flood, was excavated channel-wise to secure some capacity for debris flow passing.

(3) Source Section

Main sources of the future debris flow in this valley were placed in three parts. One was erosion site in the fans, especially G01-valley-fan, one was in the streambed between the third dam and G01-valley-fan and the other was in the reservoir of the third dam.

The exposed soil wall, length along which was around 600 meters, at the toe of the fans was still vulnerable to erosion by flash flood. The streambed between the fan and the third dam was remained sediment deposition, which was roughly estimated with 380,000 cubic meters in volume. The reservoir of the third dam had still much sediment, which was roughly estimated with 500,000 cubic meters in volume.

(4) Source Production Section

Debris sources had been produced in the upstream of the Ghyz Galeh year by year, while there two major sources production sections to the debris flow threatening at the Dasht Village; one was G01 Valley and the other was the Ghyz Galeh main stream. They did not immediately become direct source of the debris flow because of mildness of slope of the streambed.

(5) Evaluation

There was a potential of debris flow with a million cubic meters in the source section. Once flash flood occurred in the Ghyz Galeh, it should wash down the debris to some degree or another. In the worst case-scenario, the debris should overflow over the protection dike aiming to directly the village.

Therefore, MOE-North Khoransan already excavated a part of sediment section to clear the debris deposited in 2001-flood and to keep some space for the future debris flow. But it did not provide enough space for a million cubic meters debris unless the debris accumulated in the source section was stabilized or reduced.

One of the most active sources of debris flow in the Ghyz Galeh was from erosion at toe in G01-valley-fan because it was located immediate upstream of sediment section in the Dasht farmland. Direction of the flash flood in this valley went to the exposed soil wall so that every flood should scour the wall.

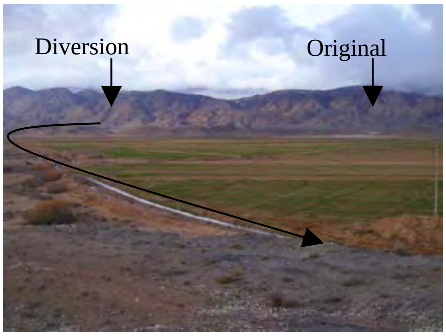
Another active source was the sediment lay between the dam and the fan, which was the direct source supplying debris to the Dasht farmland in 2001-flood and still remained with debris, which had been supplied directly from the reservoir erosion of the third dam.

Therefore, countermeasures should be prepared taking into account such sediment and erosion. Considering geographical condition, diverting the waterway to dodge from the fan erosion portion could be applicable for the countermeasure.

Ghyz Galeh: Sediment Section

Ghyz Galeh: Source Section

Ghyz Galeh: Source Section



Ghyz Galen:Diversion Route

Figure 4.15 Debris Condition in the Ghyz Galeh

(6) Required Countermeasure

1. The waterway should be diverted from the erosion portion at the fan toe of G01-Valley.
2. In order to reduce erosion force and flood load to the downstream, especially, the Dasht village and farmland areas, sabo dam with flood control function and diversion channel was proposed.
3. The third dam in the Ghyz Galeh should be restored to reduce the sediment in the reservoir.
4. The upstream area should be cared through the watershed management undertaken by MOJA Golestan.
5. The plan of the watershed management included check dams. Considering some existing dams broken, design condition on capacity of the spillway should be revised.
6. Earth dam was not recommended to adopt to sabo works, because embankment itself was vulnerable to overflowing the embankment face. In general, topography in the area applied with sabo works did not allow to provide enough space for spillway with adequate capacity.
7. Required countermeasures were designed in outline in this stage with 1/25,000 scale topographic map and some point data taken by GPS.

(7) Restoration of the Third Dam

The existing dam was located on rock base in the right side bank and on alluvial deposition layer at the left side bank. Most part of the dam body was to be placed on the alluvial layer so dam height should not exceed 15 meters from the bottom.

The design flood discharge was given with 100-year-return-period, or 350 cubic meters per second from the hydrological analysis.

(a) Location of the dam

Considering existence of rock exposed at the right side bank and consolidation under the existing dam at the left side bank, the restoration dam should be located at the place as the same as the existing one.

(b) Elevation of the spillway crest

Elevation of the spillway was set for the future sediment face to cover the existing sediment face in the reservoir area.

(c) Type of dam

Concrete gravity type was proposed unlike the existing earth dam.

(d) Foundation

The foundation should placed on a solid riverbed. In this stage of the study, geological exploration was not carried out yet so soundness of the foundation should be confirmed by sampling with core boring and permeability tests in the next stage. In case deep, loose or highly permeable foundation was turned out, additional foundation improvement works should be required that was excluded in the mater plan.

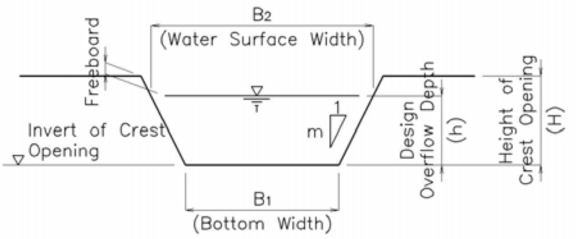
(e) Other dimensions

The other dimensions were adopted with the conventional method as follows;

The following formula was adopted to determine dimensions of the spillway;

Or

Design discharge is provided from the formula below.



$$Q = \frac{2}{15} C \sqrt{2g} (3B_1 + 2B_2) h^{3/2}$$

where;

Q : design discharge (m^3/s); 350

C : coefficient of discharge flow (0.60~0.66); 0.6

g: gravitational acceleration (9.8 m/s^2)

B_1 : bottom width of spillway (m)

B_2 : width of water surface of overflow (m)

m : side slope gradient (for vertical scale); 0.5

h : design depth of overflow at the crown of spillway

When C = 0.6 and m = 0.5 are substituted for the above formula, the formula can be simplified, as follows:

$$Q = (0.71h + 1.77B_1) h^{3/2}$$

Regarding the required freeboard for spillway, it shall consider the relation between design discharge and the required freeboard shown in the following table.

Freeboard of Spillway

Design Discharge	Freeboard
Below 200 m^3/s	0.6 m
200 to less than 500 m^3/s	0.8 m
More than 500 m^3/s	1.0 m

When the spillway section is to be finally determined, the proposed spillway section shall be adequate to flow the design discharge including sediment, safely.

Considering minimizing the dam height and the site condition, the following combination was adopted.

B_1: 100 m

h : 1.6 m

Freeboard: 0.8 m, and

Gradient of wing wall: 2 % , which was taken from that of existing riverbed.

Thickness of the crest of spillway was referred from the following table, and adopted as follow;

Thickness of the crown of spillway: 3.0 m

Thickness of Dam Crest for Concrete Sabo Dam

Thickness of Crest, (W)	1.5~ 2.5 m	3.0~ 4.0 m
Streambed material structure	Sand and Gravel~ Gravel and Cobble	Cobble and Boulder
Condition of sediment flow	Sediment discharge	Debris flow

Typical cross-section was given following the conventional cross-section of sabo dam. At the stage of feasibility study, stability calculation should be closely made for dam safety.

Apron length was adopted with 25 m from the experimental formula formulated based on Japanese implementation on the concerning projects.

Those designs were given for this stage only by the conventional method without detailed consideration. Therefore, the designs should be revised in the next stage based on the data additionally taken.

(8) The Fourth Dam with Flood Control

To prevent debris flow and flood from the Ghyz Galeh directing to the Dasht Village, reducing flood intensity to 25-year-return-period level, flood control structure of sabo dam type was proposed.

The design flood discharge for spillway was made based on the discharge, 100-year return period, or 350 cu.m/sec, and for flood control slit, 25-year return period, or 150 cu.m/sec.

(a) Location of the dam

Location of the flood control dam, hereafter called as the fourth dam, was selected as the place around 400 m downstream of the third dam location because of existence of sound rock projection at the right hand side.

(b) Elevation of spillway and slit crests

Elevation of the slit crest was set for the future sediment face to reach the foot of the third dam structure and that of spillway was set with required height of flood control slit.

(c) Type of dam

Concrete gravity type was proposed because it had a slit structure as spillway for flood control, through which flood flew with high velocity.

(d) Foundation

The foundation should placed on a solid riverbed. In this stage of the study, geological exploration was not carried out yet so soundness of the foundation should be confirmed by sampling with core boring and permeability tests in the next stage. In case deep, loose or highly permeable foundation was turned out, additional foundation improvement works should be required that was excluded in the mater plan.

(e) Dimensions of the flood control slit

The width of slit was set with 4 m in width considering maximum size of stone in this area so as to pass through the slit without clogging, and with 4.5 m in high to discharge the design flow, 150 cu.m/s in 25-year return period.

(d) Other dimensions

The dimensions were set as the same way as mentioned in the item above. Apron structure should be revised to resist against high velocity flow in the next study stage.

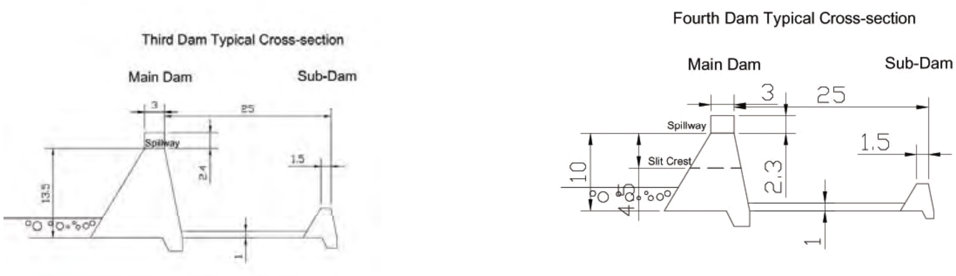


Figure 4.16 Typical Cross-section of Proposed Sabo Dams

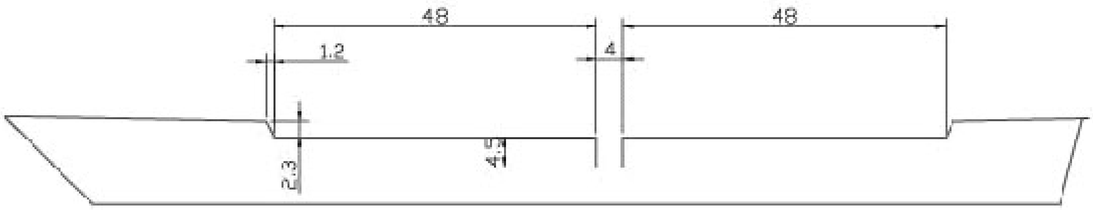


Figure 4.17 Upstream Face of Sd4 for Flood Control

(9) Diversion Channel

Diversion channel was proposed for the waterway of the Ghyz Galeh to divert from the original way to the farmland through short cut way shown as follows;

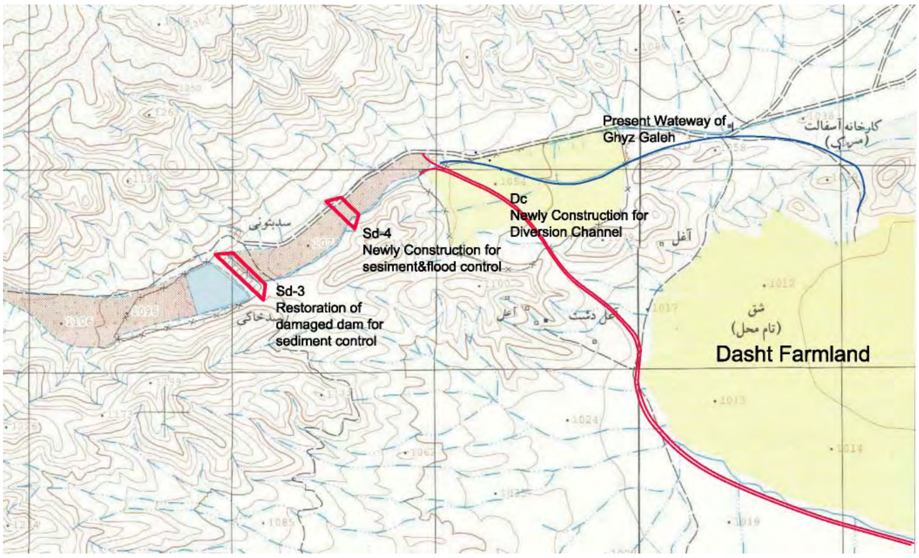


Figure 4.18 Location Map of Countermeasures in the Ghyz Galeh

The diversion channel was designed for flow capacity with 150 cu.m/sec in 25-year return period adopting Manning formula that gave a typical channel cross-section with 20 m in bottom width, 1:2 in gradient of slope in cross-section of the channel.

(10) Public Hearing

The Team proposed diversion channel and erosion protection works and explained on necessity of the project and land acquisition for excavation space of the channel.

The residents representatives agreed with the proposal, especially expressed strongly necessity of the diversion channel because they also had been eager for such works since immediate after 2001-flood.

They also discussed how to secure a safety before such works done and recognized a necessity of risk management.

One of the participants, who owned a land concerned with the project, declined to give up the land so they confirmed to continue the discussion on this matter.

Some of them expressed that they had been discussing about permanent whole-village relocation to the safer place.

SUPPORTING REPORT I (MASTER PLAN)

<u>PAPER X</u>

River Engineering and Sediment Control

THE STUDY ON FLOOD AND DEBRIS FLOW IN THE CASPIAN COASTAL AREA FOCUSING ON THE FLOOD-HIT REGION IN GOLESTAN PROVINCE

SUPPORTING REPORT I (MASTER PLAN)

PAPER X RIVER ENGINEERING AND SEDIMENT CONTROL

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CHAPTER 1 URGENT RESTORATION PROJECTS AFTER 2001 AND 2002 FLOODS AND FUTURE IMPROVEMENT PROGRAM

1.1 Summary on Damages of infrastructure

Many kinds of infrastructure along the Madarsoo River have been devastated caused by the two times huge flooding in 2001 and 2002. Those main damages from river engineering point of view are itemized as follows;

1. Loss and collapse of roads and bridges
2. Bank erosion along the river courses
3. Debris deposition in farmlands, villages and roads
4. Breach of five existing dams in the Ghyz Ghaleh and the Dasht-e-Sheikh rivers

1.2 Required Countermeasures of Governmental Organizations

The plan and implementation of projects for restoration of damaged infrastructure and prevention of recurrence have been conducted by the governmental organizations concerned from the huge flood damages occurrence. Mainly three (3) governmental organizations, which are Ministry of Jihad-e-Agriculture, Ministry of Energy and Ministry of Road and Transportation (hereinafter referred to as MOJA, MOE and MORT, respectively), have coordinated with the said projects in accordance with their jurisdictions.

The projects of MOE and MORT have been mainly aimed for rehabilitation of the damaged infrastructures and restoration of the least original function while that of MOJA for mitigation of damages in recurrence.

The principle of the jurisdiction of the projects is:

1. MOJA is responsible for flood, erosion and debris/sediment control in watershed management;
2. MOE is responsible for flood and erosion control in river improvement; and
3. MORT is responsible for restoration of damaged roads and bridges.

Implementation of the projects has been carried out by the organization of the province, which the location of the project belonged to, except for some MOJA projects.

1.3 MOJA Urgent Projects

MOJA has a conceptual master plan, which belongs to the third National Five-Year Plan, in the Golestan Dam basin including the Madarsoo River basin. Scope of the master plan consists of the followings as watershed management in the Golestan Dam basin.

1. To conserve/ restore natural condition
2. To promote sustainable development on social-economical activity
3. To protect natural environment and human activities from water-related destruction
4. To reduce and control flood peak discharge

According to the said master plan, MOJA has determined to implement the urgent projects to reduce physical damages caused by the probable flood and debris flow in five (5) sub-basins of the Madarsoo River basin.

Those projects aim to 1) to reduce the probable flood peak discharge with the water storage function of the proposed countermeasures, 2) to accelerate the infiltration of flooding water stored by the proposed countermeasures and 3) to control the erosion in the hillsides with the proposed countermeasures.

The urgent projects have been formulated concretely on 2002 after 2001 flood and a part of its implementation has been completed as of September 2005.

The overall location map of those projects in the Madarsoo River basin is shown in Figure 1.1;

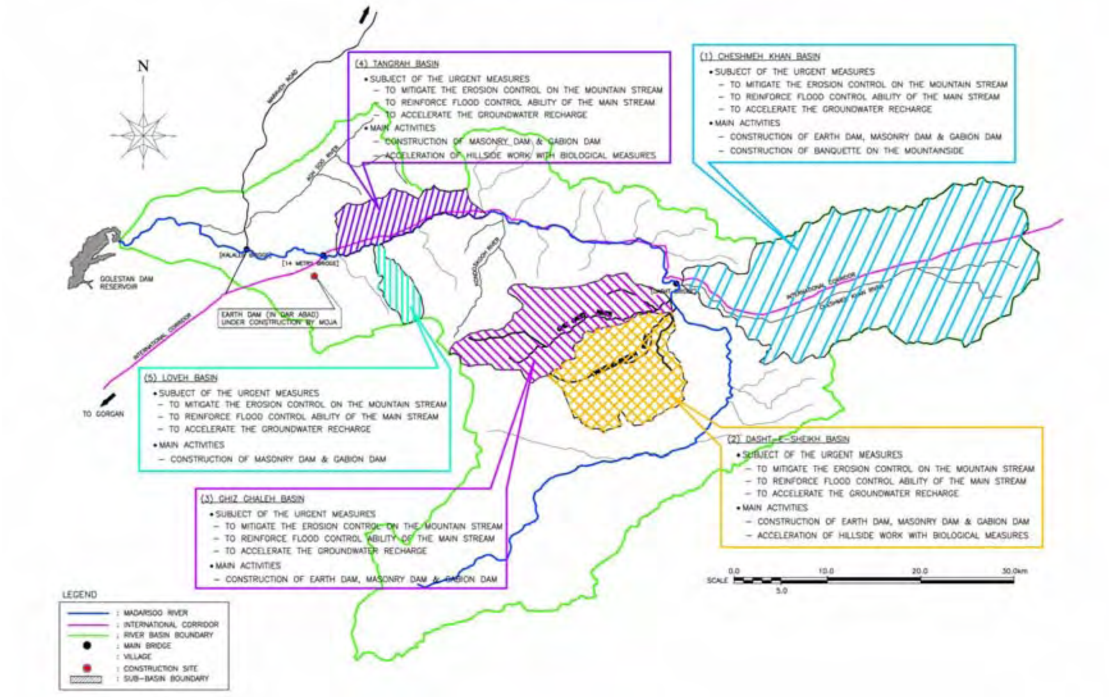

Figure 1.1 Overall Location of the Urgent Measures Proposed by MOJA

The project features in the urgent projects are described as follows;

(1) Cheshmeh Khan Sub-Basin

This sub-basin has a catchment area of 452 km^2 and the Cheshmeh Khan River runs from west to east side in the muddle of this sub-basin.

This project is planned to implement the prevention of existing farmlands from sediment deposition caused by floods and erosion in the hillsides.

The project objective and main structural measures are mentioned as follows:

(a) Project Objective

1. To mitigate the erosion control on the mountain stream

2. To reinforce flood control ability of the main stream

(b) Main Activities

1. Construction of earth dam, a series of masonry or gabion dams

2. Execution of hillside works with biological measures such as changing dry farming, fertilizing in range land, seeding in range land, mass seeding, planting and planting tree in the forest area

Further, MOJA will expect this project to accelerate the groundwater recharge for the irrigated farmlands and to reduce the flood peak discharge with the proposed earth dam.

The project features are tabulated in Table 1.1.

Table 1.1 Project Features for Cheshmeh Khan Sub-Basin

Countermeasures	Quantity	Implementation Schedule	Estimated Cost (Million Rials)
Earth Dam	5 nos.	N/A	N/A
Masonry Dam	21 nos.	2 years	383.8
Gabion Dam	36 nos.	2 years	324.8
Banquetting	145 ha	2 years	45.3
Mass Seeding	2,939 ha	8 years	882.4
Planting	2,630 ha	7 years	2,439.0
Total			4,075.3

Source: MOJA Golestan Office

(2) Dasht-e-Sheikh Sub-Basin

This sub-basin has a catchment area of 125 km^2. The Dasht-e-Sheikh River runs from southeast to northwest side in the muddle of this sub-basin and the downstream end of this river meets the the Gelman Darreh River nearby the Dasht Village.

This project is planned to implement the prevention of existing farmlands from sediment deposition and erosion in the hillsides.

The project objective and main structural measures are mentioned as follows:

(a) Project Objective

1. To mitigate the erosion control on the mountain stream
2. To reinforce flood control ability of the main stream

(b) Main Activities

1. Construction of earth dam, a series of masonry or gabion dams
2. Acceleration of hillside works with biological measures such as changing dry farming, fertilizing in range land, seeding in range land, mass seeding, planting and planting tree in the forest area

Further, this project is expected to accelerate the groundwater recharge for the irrigated farmlands, to promote the biological measures, which are like fertilizing, tree planting, seeding and terracing, and to reduce the flood peak discharge by MOJA.

The project features are shown as follows:

Table 1.2 Project Features for Dasht-e-Sheikh Sub-Basin

Countermeasures	Quantity	Implementation Schedule	Estimated Cost (Million Rials)
Earth Dam	7 nos.	1 year	4,514.1
Masonry Dam	35 nos.	6 years	6,944.0
Gabion Dam	36 nos.	1 year	789.3
Terracing	120 ha	5 years	3,373.1
Banquetting	1,740 ha	5 years	1,305.0
Furrow	2,850 ha	6 years	712.5
Changing dry farming	140 ha	5 years	2,824.0
Fertilizing in rangeland	6,000 ha	8 years	541.4
Seeding in rangeland	4,200 ha	6 years	655.2
Mass Seeding	240 ha	3 years	72.0
Planting (Forest)		6 years	6,078.2
Supporting of drinking water for seep	32 nos.	4 years	160.0
Total			27,968.8

Source: MOJA Golestan Office

The arrangement of structural measures including the dam construction and farmland improvement is shown in Figure 1.2 as follows. This arrangement map is obtained from the Watershed Management Division of MOJA- Golestan Office.

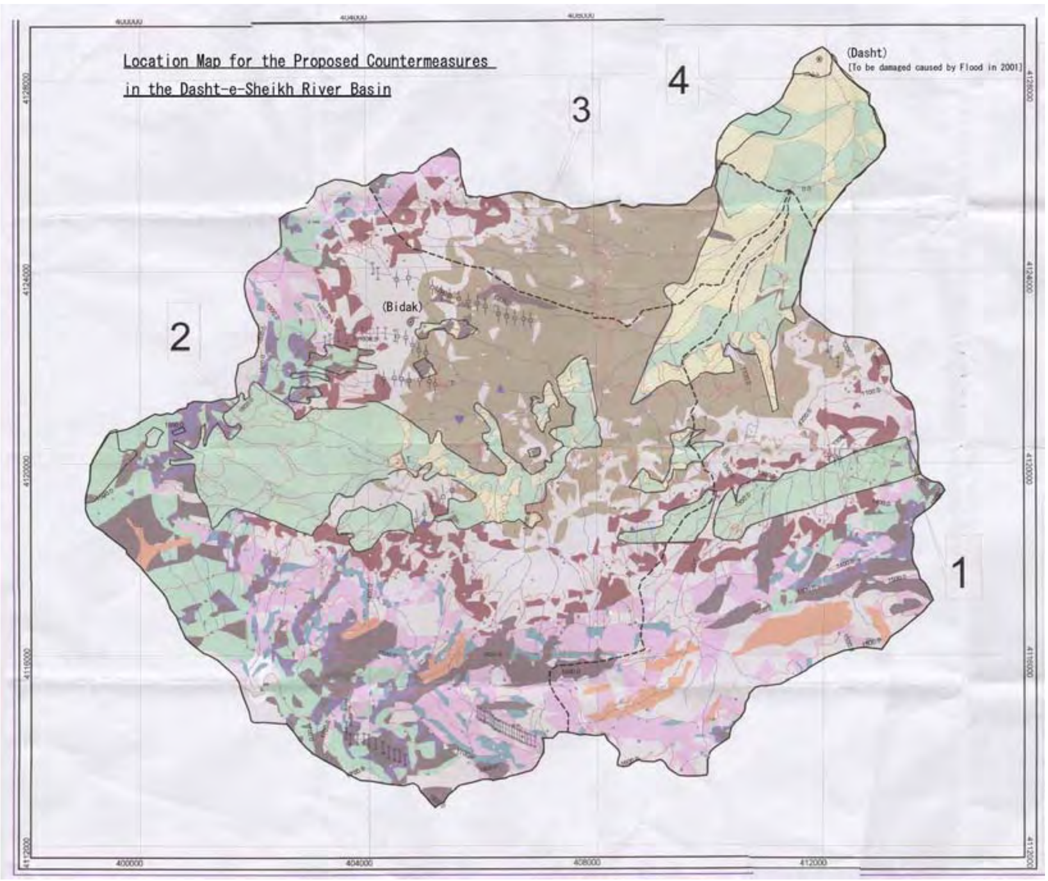

Figure 1.2 Urgent Measures in the Dasht-e-Sheikh Sub-Basin

(3) Ghyz Ghaleh Sub-Basin

This sub-basin has a catchment area of 126 km^2. The Ghyz Ghaleh River runs from east to west side in the muddle of this sub-basin and the downstream end of this river meets the Madarsoo River nearby the Dasht Village.

This project is planned to implement the prevention of existing farmlands from sediment deposition caused by floods and erosion in the hillsides.

The project objective and main structural measures are mentioned as follows:

(a) Project Objective

1. To mitigate the erosion control on the mountain stream
2. To reinforce flood control ability of the main stream

(b) Main Activities

1. Construction of earth dam, a series of masonry or gabion dams
2. Execution of hillside works with biological measures such as changing dry farming, fertilizing in range land, seeding in range land, mass seeding, planting and planting tree in the forest area

Further, this project is expected to accelerate the groundwater recharge for the irrigated farmlands and to reduce the flood peak discharge by MOJA.

In addition, a part of the northern riverbank of the Ghyz Ghaleh River is corresponding with the boundary for the Golestan National Park (hereinafter referred to as G.N.P).

Therefore, this project also has the essential objective for the environmental conservation to G.N.P.

The project features are tabulated in Table 1.3.

Table 1.3 Project Features for Ghyz Ghaleh Sub-Basin

Countermeasures	Quantity	Implementation Schedule	Estimated Cost (Million Rials)
Earth Dam	18 nos.	N/A	N/A
Masonry Dam	49 nos.	3 years	11,134.0
Gabion Dam	25 nos.	2 years	546.2
Terracing	125 ha	5 years	3,013.3
Banquetting	180 ha	5 years	135.0
Changing dry farming	500 ha	5 years	10,000.0
Fertilizing in rangeland	2,700 ha	4 years	243.7
Seeding in rangeland	2,700 ha	4 years	421.4
Mass seeding	70 ha	2 years	21.0
Supporting of drinking water for seep	9 nos.	2 years	45.0
Miscellaneous			1,142.5
Total			26,702.1

Source: MOJA Golestan Office

The arrangement of structural measures including the dam construction and farmland improvement is shown in Figure 1.3 as follows. This arrangement map is obtained from the Watershed Management Division of MOJA- Golestan Office.

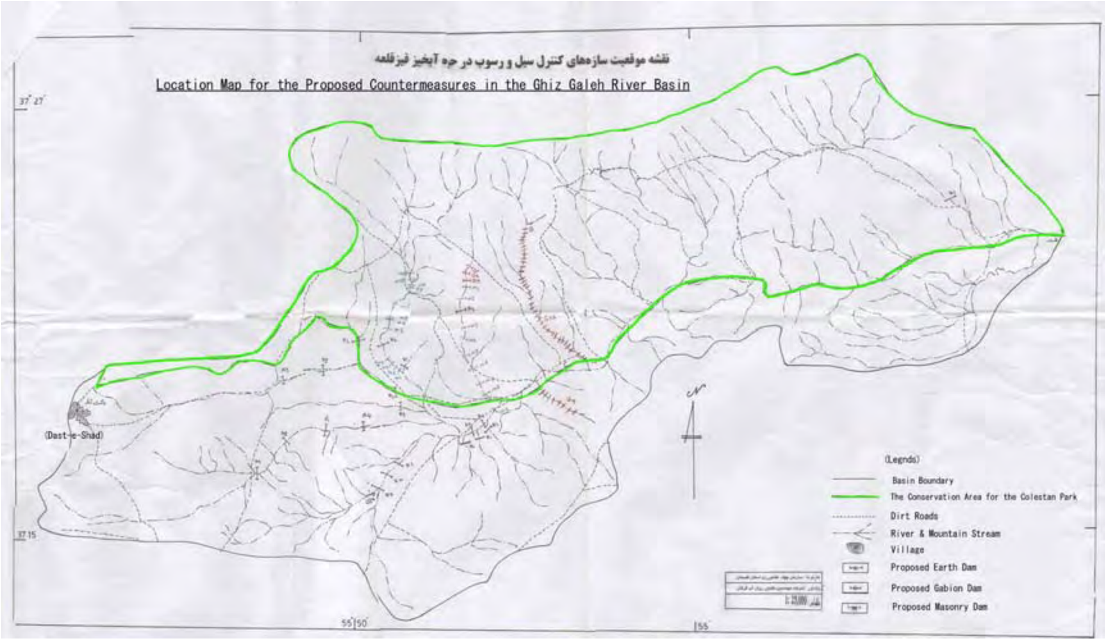

Figure 1.3 Urgent Measures in the Ghyz Ghaleh Sub-Basin

(4) Tangrah Sub-Basin

The Tangrarh sub-basin has a catchment area of 362 km^2. This proposed plan is limited to implement in a part of the sub-basin, which is located on the northern part of the Madarsoo River. The debris flow caused by 2001 Flood has damaged the Terjenly Village directly and several residential houses have been broken and/or barred by the debris flow.

This project is planned to implement the prevention of existing farmlands from sediment deposition and erosion in the hillsides.

(a) Project Objective

1. To mitigate the erosion control on the mountain stream
2. To reinforce flood control ability of the main stream

(b) Main Activities

1. Construction of a series of masonry or gabion dams
2. Construction of new waterway in the Terjenly Village to protect the human life and properties from the flood flow discharging into the Madarsoo River
3. Execution of hillside works with biological measures such as changing dry farming, fertilizing in range land, seeding in range land, mass seeding, planting and planting tree in the forest area

Further, this project is expected to accelerate the groundwater recharge for the irrigated farmlands, to promote the biological measures, which are like fertilizing, tree planting, seeding and terracing, and to reduce the flood peak discharge by MOJA.

The project features are shown as follows:

Table 1.4 Project Features for Tangrah Sub-Basin

Countermeasures	Quantity	Implementation Schedule	Estimated Cost (Million Rials)
Masonry Dam	9 nos.	1 year	1,641.9
Gabion Dam	42 nos.	1 year	672.8
Channel Works	900 m	1 year	5,000.0
Terracing	200 ha	8 years	5,620.0
Banquetting	1,740 ha	5 years	1,170.0
Furrow	2,650 ha	6 years	712.5
Mass Seeding	180 ha	7 years	51.0
Planting	180 ha	1 year	750.0
Tending Forest	767 ha	5 years	767.0
Cleaning Forest	42 ha	5 years	16.8
Seeding Forest	35 ha	1 year	17.5
Planting Forest	150 ha	1 year	375.0
Miscellaneous			1,134.1
Total			17,928.6

Source: MOJA Golestan Office

In addition to the channel works in the above table, the proposed channel works is located in Terjenly village and the waterway, which is connected with the Madarsoo River, will be designed to prevent the flood and/or debris flow from spreading into the conservation area.

The arrangement of structural measures including the dam construction and farmland improvement is shown in Figure 1.4 as follows. This arrangement map is obtained from the Watershed Management Division of MOJA- Golestan Office.

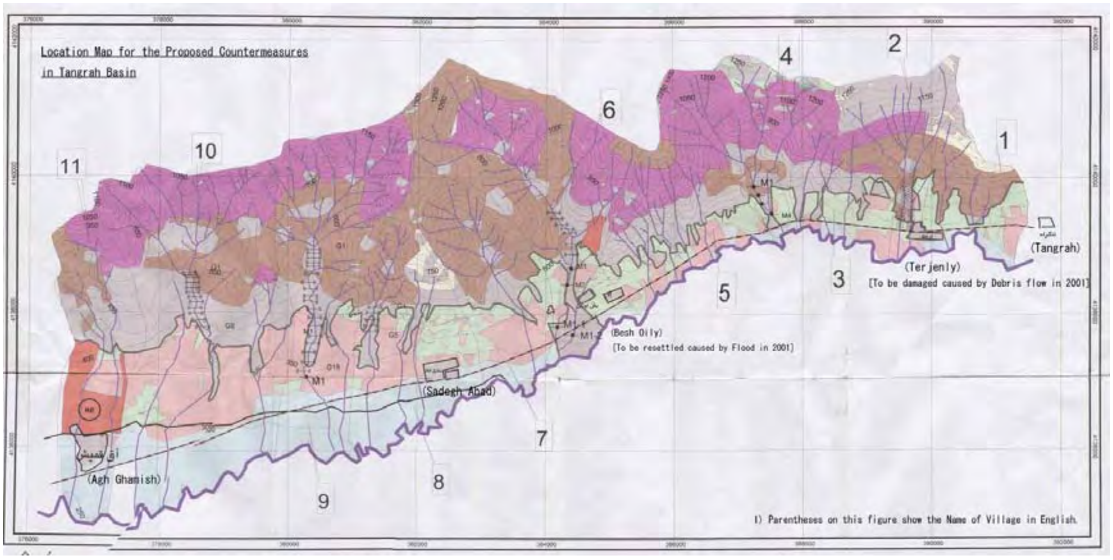

Figure 1.4 Urgent Measures in the Tangrah Sub-Basin

(5) Loveh Sub-Basin

This project is planned to implement the prevention of existing farmlands from sediment deposition caused by floods and erosion in the hillsides.

Further, this project is expected to accelerate the groundwater recharge for the irrigated farmlands and to reduce the flood peak discharge.

The project features are tabulated in Table 1.5.

Table 1.5 Project Features for Loveh Sub-Basin

Countermeasures	Quantity	Implementation Schedule	Estimated Cost (Million Rials)
Masonry Dam	6 nos.	One year	816.0
Gabion Dam	21 nos.	One year	236.0
Total			1,052.0

Source: MOJA Golestan

The arrangement of structural measures including the dam construction and farmland improvement is shown in as follows. This arrangement map is obtained from the Watershed Management Division of MOJA- Golestan Office.

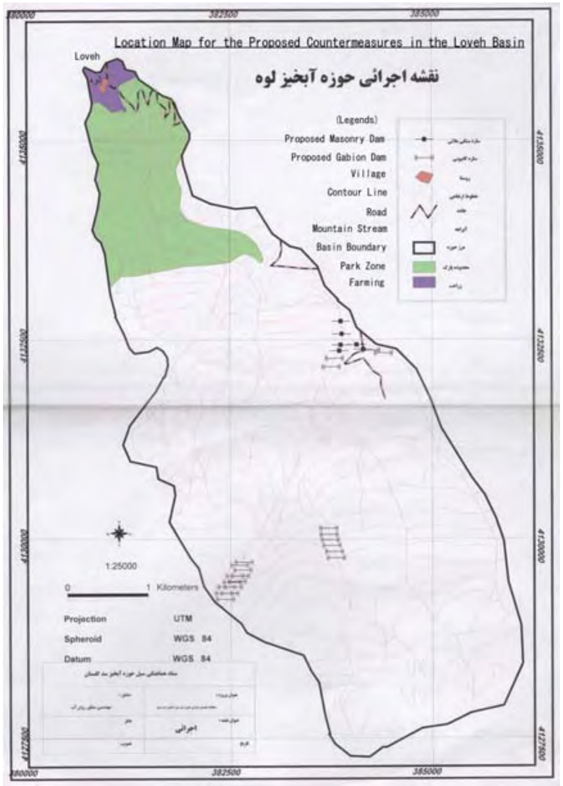

Figure 1.5 Urgent Measures in the Love Sub-Basin

1.4 MOE Urgent Projects

MOE has conducted the river improvement plan with the Urgent Measures in the Madarsoo River basin since the flood occurrence in 2001 has seriously damaged the roads, bridges and riverbanks along the river course.

The river improvement stretch proposed by MOE is approximately 65 km from Kalaleh Bridge to Dasht Bridge along the river including the Golestan National Park area. The design discharge in the plan is ranged between 250 m^3/s of the upstream (nearby Golestan National Park) and 400 m^3/s of the downstream (nearby the Kalaleh Bridge) in accordance with a 50-year return period.

In order to protect the essential infrastructures along the Madarsoo River from the further probable flood damages, MOE has determined to execute the river urgent improvements of the nine locations. The elaborated plans include the protection works of the existing road system against flood and/or debris flow in association with MORT as well as river widening to accommodate the probable flood.

In addition, MOE has simultaneously conducted to formulate the Master Plan in accordance with a 100-year return period for the Gorgan Dam Basin including the Madarsoo River basin.

However, as of January 2005, the Master Plan has not been finalized yet due to the continuation of the study by MOE staff.

Unfortunately, the flood has been happened in August 2005. The flood has seriously damaged the riverbank protections, which are composed of the MOE urgent measures, along the Madarsoo River.

Consequently, MOE Golestan Office is carrying out the overall review for the Master Plan and urgent measures in terms of hydraulic conditions, riparian structures strengthening and structural arrangements.

The following information is described for the urgent measures undertaken by MOE before the 2005 Flood occurrence.

Figure 1.6 shows the location of the respective scheme conducted by MOE and the said features are tabulated below.

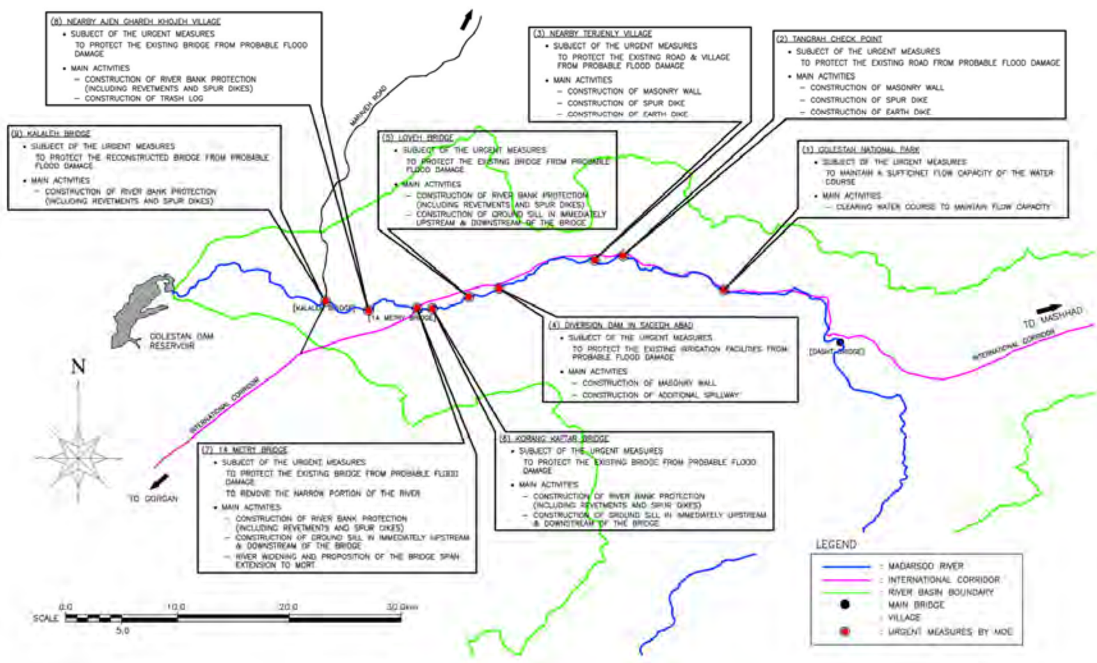

Figure 1.6 Location of the Urgent Measures Proposed by MOE

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(1) Golestan National Park	Riverbed Clearing		To be reviewed caused by the damage of August 2005 Flood

The subject is to maintain the existing watercourse.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(2) Tangrah Check Point (Right Bank)	Masonry Wall	L=700m, H=3.5 to 4.0m	To be reviewed caused by the damage of August 2005 Flood
	Groin (Riprap type)	L=10m, 69nos.@10m	
	Earth Dike with/without slope protection	Slope Gradient =1:2.0 Dike Crest Width =4.0m	

The subject is to protect the existing roads from probable flood.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(3) Terjenly (Right Bank)	Masonry Wall	L=400m, H=3.5 to 5.5m	To be reviewed caused by the damage of August 2005 Flood
	Groin (Riprap type)	L=10m, 69nos.@10m	
	Earth Dike with/without slope protection	L=550m Slope Gradient =1:2.0 Dike Crest Width =4.0m	

The subject is to protect the existing roads and village properties from probable flood.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(4) Diversion Dam in Sadegh Abad	Masonry Wall (Right Side)		To be reviewed caused by the damage of August 2005 Flood
	Diversion Weir (Addition to existing weir)	L=20m, W=60m, h=2m (Gabion Mattress type= 1.0mX1.0mX2.0m)	

The subject is to protect the existing irrigation facilities from probable flood.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(5) Loveh Bridge	Masonry Wall		To be reviewed caused by the damage of August 2005 Flood
	Groin (Riprap type)		
	Earth Dike with/without slope protection	L=600m Slope Gradient =1:2.0 Dike Crest Width =4.0m	
	Ground Sill	H=2.0m	

The subject is to protect the existing bridges from probable flood.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(6) Korang Kaftar Bridge	Groin (Riprap type)		To be reviewed caused by the damage of August 2005 Flood
	Earth Dike with/without slope protection	Slope Gradient =1:2.0 Dike Crest Width =4.0m	
	Ground Sill	H=2.0m	

The subject is to protect the existing bridge from probable flood.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(7) 14 Metry Bridge	Masonry Pitching	L=650m, Slope Gradient = 1:2.0 Dike Crest Width =4.0m	To be reviewed caused by the damage of August 2005 Flood
	Masonry Wall		
	Ground Sill	H=2.0m	

The subject is to protect the existing bridge from probable flood and to remove the narrow portion of the river.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(8) Ajen Ghareh Khojeh	Earth Dike with/without slope protection (Right Bank)	L=1,200m Slope Gradient =1:2.0 Dike Crest Width =4.0m	To be reviewed caused by the damage of August 2005 Flood
	Groin (Riprap type)		
	Masonry Wall (Left Bank)	L=250m	
	Trash Log	1 nos.	

The subject is to protect the existing bridge from probable flood.

Location	Features of the Proposed Structures		Current Status (As of Jan. 2005)
	Structural Type	Work Volume	
(9) Kalaleh Bridge	Masonry Wall		To be reviewed caused by the damage of August 2005 Flood
	Groin (Riprap type)		

The subject is to protect the reconstructed bridge and natural levee in the bending portion of the watercourse from probable flood.