MINISTRY OF JIHAD-E-AGRICULTURE
THE ISLAMIC REPUBLIC OF IRAN

No.

# THE STUDY
# ON
# FLOOD AND DEBRIS FLOW IN THE CASPIAN COASTAL AREA FOCUSING ON THE FLOOD-HIT REGION IN GOLESTAN PROVINCE
# IN
# THE ISLAMIC REPUBLIC OF IRAN

## FINAL REPORT

## VOLUME II
## SUMMARY

OCTOBER 2006

Japan International Cooperation Agency

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MINISTRY OF JIHAD-E-AGRICULTURE
THE ISLAMIC REPUBLIC OF IRAN

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

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## VOLUME II
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OCTOBER 2006

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

## Composition of Final Report

| | |
|---|---|
| **Volume I** | **Main Report** |
| **Volume II** | **Summary** |
| **Volume III-1** | **Support Report 1: Master Plan** |
| **Volume III-2** | **Support Report 2: Feasibility Study** |
| **Volume IV** | **Data Book** |

**PROJECT COST ESTIMATE**

| | |
|---|---|
| Price Level | : Average Prevailing Market Price in August 2005 |
| Currency Exchange Rate | : USD 1 = 8,996 Rials and JPY 100 = 8,025 Rials |

# PREFACE

In response to a request from the Government of the Islamic Republic of Iran, the Government of Japan decided to conduct the Study on Flood and Debris Flow in the Caspian Coastal Area Focusing on the Flood-Hit Region in Golestan Province in the Islamic Republic of Iran and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected a study team composed of staff member of CTI Engineering International Co., Ltd. The team was headed by Mr. Kanehiro MORISHITA and was dispatched to Iran four times between October 2004 and July 2006. In addition, JICA set up an advisory committee headed by Mr. Yoshifumi HARA, Director of Erosion Control Division, Public Engineering Work Department, Nagano Prefecture, for the same period, which examined the Study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Islamic Republic of Iran and conducted field surveys and studies in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and also to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Iran for their close cooperation extended to the Study.

October 2006

Ariyuki MATSUMOTO

Vice-President

Japan International Cooperation Agency

October 2006

Mr. Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

# Letter of Transmittal

Dear Sir,

It is with great pleasure that we submit herewith the Final Report of the “Study on Flood and Debris Flow in the Caspian Coastal Area Focusing on the Flood-Hit Region in Golestan Province”.

The main objectives of the Study were fourfold: (i) to formulate a master plan up to the target year 2025 for prevention of flood and debris flow disaster in the Madarsoo River basin, in which serious flood damages occurred in 2001; (ii) to select priority projects among the measures/schemes proposed in the above master plan and to carry out the feasibility study on them; (iii) to prepare technical manual and guidelines, containing planning and designing of flood and debris flow countermeasures, applicable not only to the Madarsoo basin but also to similar other basins in the Caspian coastal area; and (iv) to pursue technology transfer to counterpart personnel in the course of the Study, mainly focusing on planning and designing processes on flood and debris flow disaster mitigation and management.

Phase I of the Study examined the present conditions of the basin as the basic study, and a master plan was formulated in accordance with the above-mentioned objectives in Phase II. Subsequently in Phase III, the feasibility study was made for the selected priority projects among the master plan components. The Final Report presents the outcomes from these three phases’ studies.

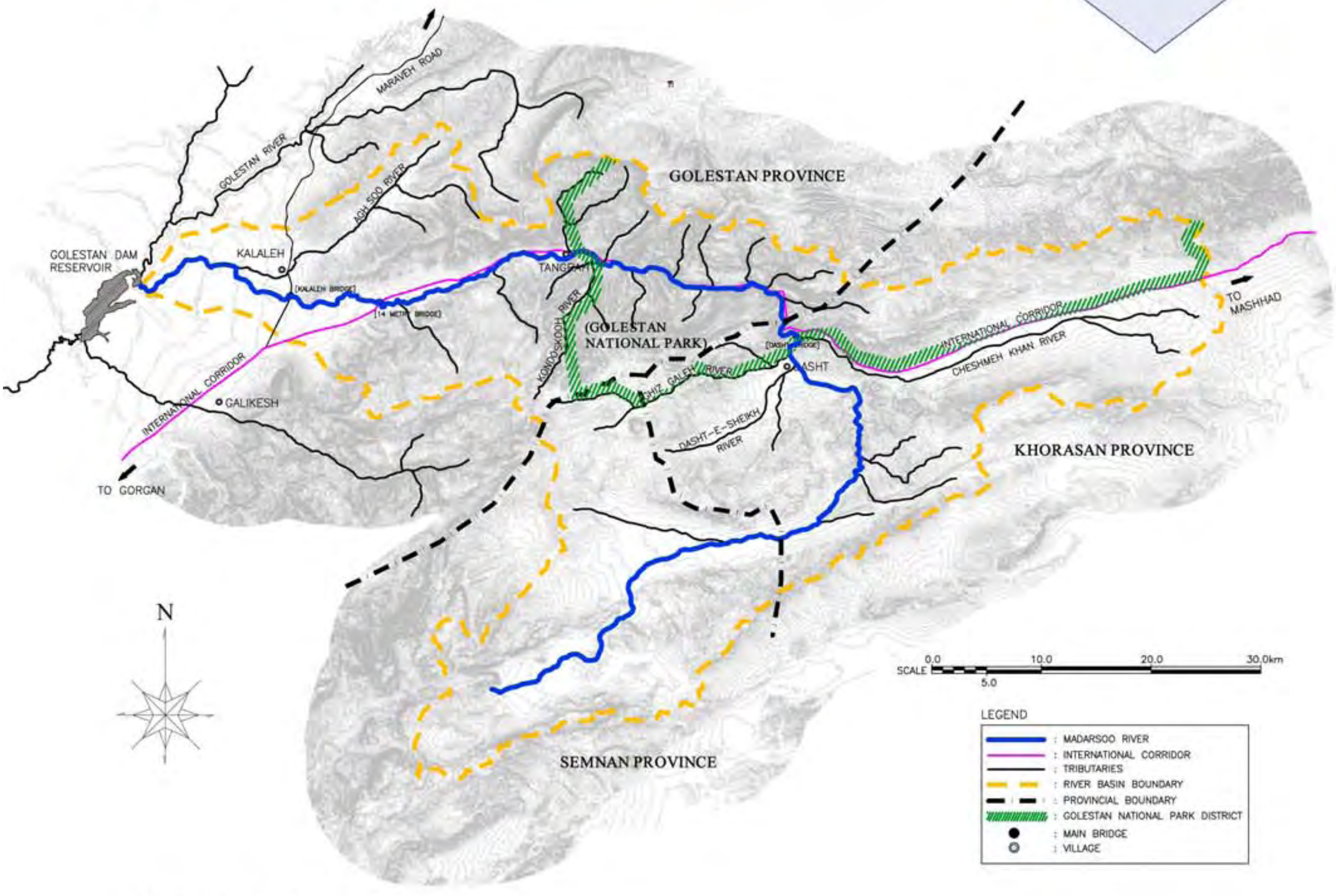
We hope this Final Report will assist strengthening disaster management activities against flood and debris flow not only for Golestan province but also for the Caspian coastal area. We believe that implementation integrating structural and non-structural measures proposed in the Report would assure further improvements in disaster management capacities of the relevant communities as well as the local governments in the long term and thus would contribute to uplifting the social welfare and living environment of people in the area.

We wish to express our sincere gratitude to the personnel concerned of your Agency and advisory committee for the guidance and support given throughout the Study period. Our deep gratitude is also expressed to the Watershed Management Deputy of the Ministry of Jihad-e-Agriculture (acted as Counterpart Agency) and other concerned authorities of the Government of the Islamic Republic of Iran, JICA Iran Office, and the Embassy of Japan in Iran for their close cooperation and assistance extended during the course of the Study.

Very truly yours,

Kanehiro MORISHITA
Team Leader
The Study on Flood and Debris Flow in the Caspian
Coastal Area Focusing on the Flood-Hit Region in
Golestan Province in the Islamic Republic of Iran


The Islamic Republic of Iran




The Madarsoo River Basin

# General Map for the Study Area

**MASTER PLAN FORMULATION**

## 1 MASTER PLAN CONCEPT

The master plan for flood and debris flow mitigation and management shall cover the entire fields and processes of flood disaster occurrence and response, 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.

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.

The target year of the master plan shall be set in the year 2025. Furthermore 25-year flood for protecting farmlands and rural villages and 100-year flood for protecting important structures (trunk road and bridges) and town areas are adopted as hydrological design scales in the master plan.

## 2 MASTERPLAN COMPONENT

After selection of suitable and effective countermeasures, 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.

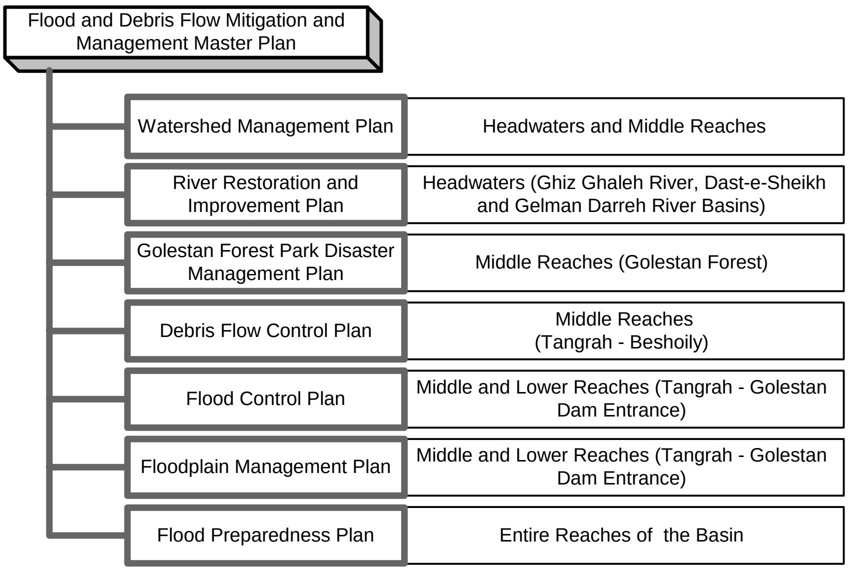



**Fig. 1 Master Plan Components for Flood and Debris Flow Mitigation and Management**

# 3 PROJECT COST AND EVALUATION

Table 1 summarizes the proposed master plan components and their costs. The master plan integrates newly proposed plans and on-going projects since they are closely related each other. Watershed management plan, including debris flow control plan, is being conducted by MOJA, and flood control plan is also being conducted as a rehabilitation part by MOE and MORT.

**Table 1 Summary of the Proposed Master Plan Component and Sub-Scheme**

| Master Plan Component | | Sub-Scheme | Component/Scheme Digest | Project Cost (million Rials) |
|---|---|---|---|---|
| 1 | Watershed Management Plan | 5 sub-basins | Conducting improvement measures combining mechanical, bio-mechanical and biological engineering measures | 79,374 |
| 2 | River Restoration and Improvement Plan | Ghiz Ghaleh | Rehabilitating the damaged earth dam to consolidate stored sediment and constructing channel system in Ghiz Ghaleh | 55,890 |
| | | Gelman Darreh and Dasht-e-Sheikh | Constructing channel system in the Gelman Darreh and Dasht-e-Sheikh | 195,200 |
| 3 | Golestan Forest Disaster Management Plan | Flood forecasting and warning system | Improving existing meteo-hydrologic monitoring system, data transmission and processing system to utilize real time data for flood forecasting, and installing warning posts | 3,300 |
| 4 | Debris Flow Control Plan | (Assistance for MOJA activities) | Constructing sediment control structures and channeling works in debris flow affected villages | - |
| 5 | Flood Control Plan | (Recommendation to MOE and MORT plans) | Rehabilitating damaged structures in both of the 2001 and 2005 floods and establishing the master plan for the Golestan dam basin | - |
| 6 | Floodplain Management Plan | Publication of flood hazard map | Publishing the flood and debris flow hazard map and utilizing it for evacuation activities and land use management | - |
| 7 | Flood Preparedness Plan | Extension of flood warning system | Installing warning posts at villages located in the middle and lower reaches to announce the flood warning to the villagers | 3,300 |
| | | Educational assistance | Conducting education and awareness of flood hazard and training exercise for strengthening community-based disaster management | - |

Regarding project evaluation, quantitative economic evaluation was made in two components as tabulated below. Both projects could be regarded as viable ones from the estimated EIRR and project nature of disaster management.

**Table 2 Estimated EIRR in the Proposed Master Plan Components**

| | Under Present Condition | Under Year 2025 Condition |
|---|---|---|
| River Restoration and Improvement Plan | 8.86 % | 9.38 % |
| Golestan Forest Disaster Management Plan | 10.47 % | 15.06 % |

As for environmental and social evaluation, all of the proposed projects are also considered acceptable and preferable to the localities.

**FEASIBILITY STUDY**

## 1 PRIORITY PROJECTS

From importance of project location, significance of project effects in a short period, high economic efficiency, and suitable themes for technology transfer, the following three projects were selected as priority projects.

- River restoration plan: rehabilitation of sediment control dam and riverbank stabilization works against valley-head erosion,
- Golestan Forest Park disaster management plan: establishment of flood forecasting and early warning system, and
- Flood preparedness plan: hazard map preparation and community-based disaster management.

## 2. PROJECT FEATURES

### (1) River Restoration Plan

Proposed river restoration plan is composed of two components, namely sediment control dam and river stabilization works.

Sediment control dam is planned to rehabilitate the earth dam breached in the 2001 Flood, to consolidate the stored sediment in the basin of the earth dam, and to stabilize the lower part of the Ghyz Ghaleh River channel. Through comparative study among dam type and location of floodway, earth dam type with floodway on the left bank was selected as an optimum plan. The construction cost was estimated at 12,060 million Rials (equivalent to 1.34 million USD). Its plan is presented below.

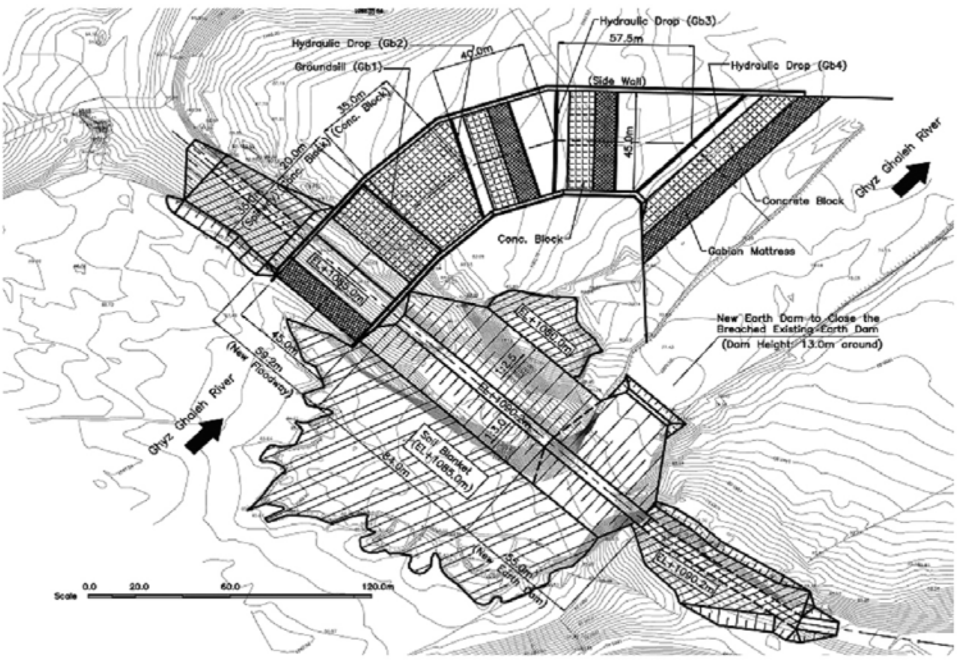



**Fig. 2 Plan of Proposed Sediment Control Dam Works**

Meanwhile, river stabilization works is planned to consolidate the valley-head erosion downstream of Dasht village, to stabilize both lower and upper channels of the proposed structure, and to protect the farmland from progressive gulley erosion. Through comparative study among concrete dam type and hydraulic drop structure type, concrete dam and hydraulic drop of a compromised type was selected as an optimum plan. The construction cost was estimated at 11,890 million Rials (equivalent to 1.32 million USD). Its plan is presented in Fig. 3.

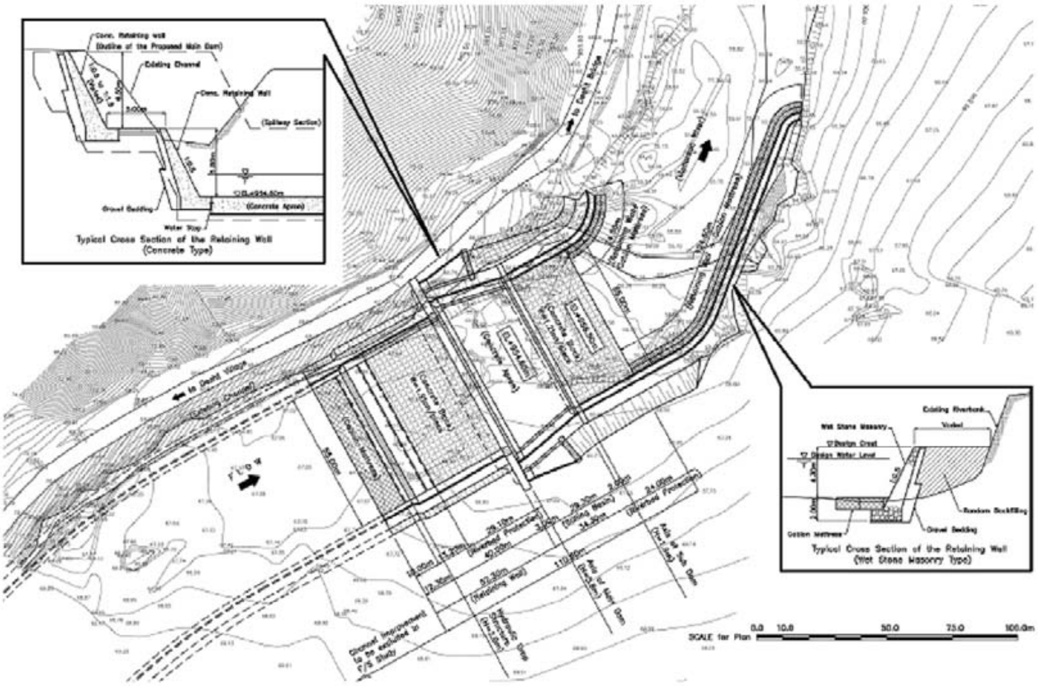



**Fig. 3 Plan of Proposed Riverbank Stabilization Works**

Implementation of construction in both works is planned for about two and half years. From the economic viewpoints, the EIRR shows 18.7 % under the present conditions and 19.2 % under the future (year 2025) conditions. These figures mean the projects have high economic viability.

From the environmental and social viewpoints, the identified negative impacts are temporary, mostly limited to appear during construction phase, and reversible. Thus these projects are recognized as controllable and socially acceptable.

### (2) Golestan Forest Disaster Management Plan

In the past two floods, 2001 and 2002, casualties concentrated in the Golestan Forest Park, and most of them were visitors and tourists. In order to save their lives from disastrous floods, early and reliable flood forecasting and warning system is indispensable.

The study aim was how to improve the present situation of meteo-hydrological observation network and forecasting and warning system. The alternatives were derived from the three conceptual improvement; namely, (1) manual system, (2) semi-automatic system, and (3) full-scale automatic system. The best combination of data collection, processing and warning sub-systems was sought among the above improvement steps through the comparative study. Finally optimum combination was selected as semi-automatic data collection, full-scale automatic data processing, and manual warning system.

The installation cost was estimated at 4,282 million Rials (equivalent to 476 thousand USD), and system installation work required about 2 years. From the economic viewpoints, the EIRR shows 7.2 % under the present conditions and 13.7 % under the future (year 2025) conditions. These figures mean the project has high economic viability. From the environmental and social viewpoints, the project is recognized as environmentally sound and socially acceptable since construction works are limited in a few spots and minimal.

Proposed flood information flow is presented in Fig. 4.

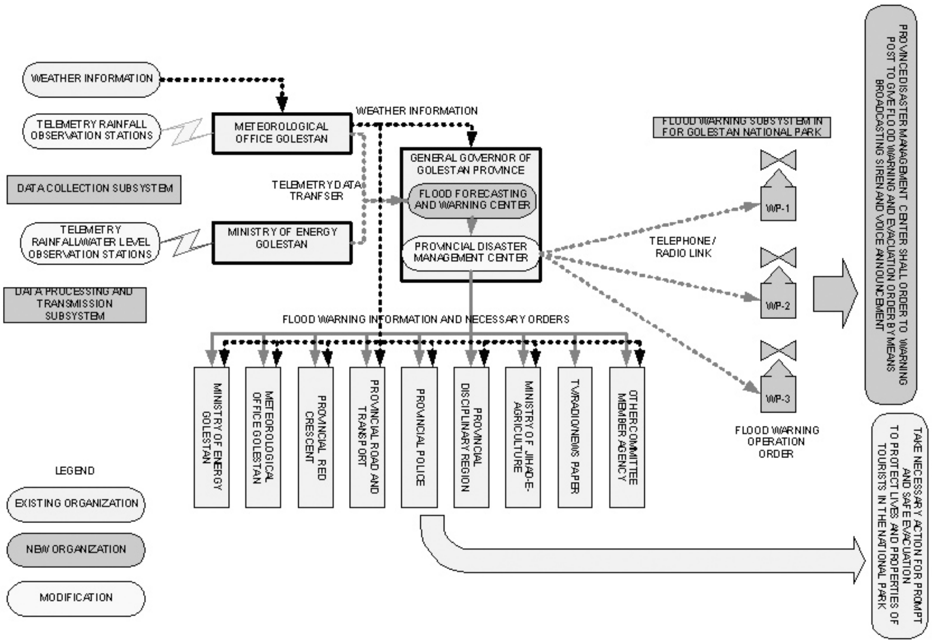



**Fig. 4 Proposed Flood Information Flow**

## (3) Flood Preparedness Plan

Flood preparedness is a generic term including activities on knowledge building, training on evacuation and rescue assuming disaster situations, improvement of disaster management units at community level. In the course of the feasibility study, the study team prepared hazard map and issued newsletter containing hazard map and evacuation route. On the other hand the team conducted a series of workshops in Terjenly and Dasht villages selected for pilot activities.

Good combination with structural and non-structural measures could realize safer situation in the river basin from flood disasters. The first project, river restoration, is purely one of the structural measures. The second one, Golestan Forest disaster management, is likely in between both measures. The third one, flood preparedness, is purely one of the non-structural measures. Thus such holistic approach in good combination between top-down measures (structural measures) and bottom-up measures (non-structural or community-based measures) could produce the most effective management frame against flood disaster.

# RECOMMENDATIONS

Throughout the study, the following recommendations could be pointed out for further progress of disaster mitigation and management against flood and debris flow in the Madarsoo River basin.

## (1) Early Implementation of River Restoration Plan

The study results are limited to the preliminary design level and it shall be conducted to further elaborate the implementation plan with the additional detailed survey, geological investigation, planning and design for the proposed structures in order to prepare the necessary documents such as detail design drawings, more precise construction quantity estimate, tender document preparation including technical specifications, etc.

According to the geological field reconnaissance, the riverbed in the Madarsoo River and the Ghyz Ghaleh River are thick covered with coarse sand, which is relatively good quality for concrete materials originated from the ancient sediment deposit in the Cambrian or Jurassic

Periods. It is recommended to conduct the detail applicable study including the design of mix proportion for the site-generated soil utilization as the concrete material on the detail design stage.

If the coarse sand of the site-generated soil could be applied to the aggregate material of the appropriate concrete, the surplus soil generated by the excavation is utilized as the useful construction materials and it is expected to reduce the construction cost of the hauling and removal of surplus soil expenses. Furthermore this research activity can provide technical guidelines of soil cement application suitable for Iranian gravels and soils, and the structures to be constructed will be a model case of sediment and erosion control structures.

### (2) Early Establishment of Flood Forecasting and Warning System and FFWC

As experienced in the 2005 Flood, early flood warning was revealed to be effective for saving human lives of visitors and campers in the Golestan Forest Park. The study indicates necessary and appropriate improvement approach in the existing meteo-hydrological monitoring and flood warning system. The study proposed that Flood Forecasting and Warning Center (FFWC) should be established in Provincial Disaster Management Center (PDMC), in accordance with the discussion made in the technical committee meeting in March 2006.

It is strongly recommended that FFWC shall be established as early as possible. Substantially FFWC has responsible for flood disaster issues in the entire Golestan province. In parallel with establishment of FFWC, improvement of the flood foresting and warning system shall be also conducted. This system will be a model case in Iran, and applicable to the similar basins in the Caspian coastal area.

### (3) Further Careful Investigation for Gelman Darreh Reservoir Scheme

After the riverbank stabilization works completion to be proposed, it is desirable to execute the channel improvement as soon as possible to reduce the flood damage occurrence in and around the Dasht village. Furthermore MOE-North Khorasan is planning the flood control dam located at the entrance of Dasht basin in the Gelman Darreh River. Such large-scale reservoir is one of the alternatives to the said river improvement. However the large-scale structure will produce significant adverse effects to the natural and social environment. Thus it is recommended that MOE-North Khorasan shall conduct careful and technical-sound investigation for the dam planning.

### (4) Necessity of Field Research and Investigation Activities

MOJA has conducted various types of countermeasures in watershed management for a long time. From planning side, however, the effects of watershed management measures are not clear yet in hydrology and meteorology. Quantitative relationship between the measures and physical effects shall be clarified for future expansion of these measures. Therefore basic research activities, which set up some experimental fields and continue to observe the meteo-hydrological parameters, are indispensable for establishment of reasonable relationship between countermeasures and their meteo-hydrological effects.

In addition, rainfall intensity curves shall be revised or newly established for hydrological designing of watershed management structures, such as sediment control dams and channel works, in accordance with accumulation of short-duration rainfall records. This work is a time taking effort to store and analyze the short-duration rainfall data over the basin/province. The short-duration rainfall monitoring has just started after the 2001 Flood in the Madarsoo River basin.

### (5) Necessity of Monitoring Activities on Sediment Transport

The Ghyz Ghaleh River is one of the large sediment yielding sub-basins in the Madarsoo basin so that the study team gives the first priority on the rehabilitation of the earth dam breached in the 2001 Flood. Sediment runoff is estimated at 200 to 400 thousand $m^3$ at the said dam-site during the 25-year design flood. Sediment runoff computation, however, usually contains the much uncertainties. Thus monitoring activities in the field is indispensable after completion of the rehabilitation in order to properly manage the excessive sediment runoff.

These monitoring activities consist of regular inspection for sediment accumulation in the downstream reaches as well as in the sedimentation basin of the dam, and seasonal inspection for conditions of mechanical and biological measures to be implemented in the watershed. Based on the monitoring results, MOJA can determine necessity of additional upstream sediment control dams. Therefore this kind of step-by-step approach is suitable and monitoring is essential particularly for the area having much sediment runoff without enough scientific/engineering information.

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

## FINAL REPORT
## VOLUME II
## SUMMARY

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## PART I MASTER PLAN

**PART II FEASIBILITY STUDY**

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## PART I MASTER PLAN

**PART II FEASIBILITY STUDY**

## ABBREVIATIONS

**Organization**

| | |
|---|---|
| DOE | Department of Environment |
| FFWC | Flood Forecasting and Warning Center |
| FRW | Forest, Rangeland and Watershed Organization |
| IUCN | International Union for Conservation of Nature |
| JICA | Japan International Cooperation Agency |
| MET | Meteorological Organization |
| MOJA | Ministry of Jihad-e-Agriculture |
| MOE | Ministry of Energy |
| MOHUD | Ministry of Housing and Urban Development |
| MOI | Ministry of Interior |
| MORT | Ministry of Roads and Transportations |
| MPO | Management and Planning Organization |
| NRGO | Natural Resource General Office |
| PDMC | Provincial Disaster Management Committee |
| RCS | Red Crescent Society |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| WMO | World Meteorological Organization |

**Technical Terms**

| | |
|---|---|
| ADSL | Asymmetric Digital Subscriber Line |
| B/C | Benefit - Cost Ratio |
| BCD | Binary Coded Decimal |
| CPT | Cone Penetration Test |
| CSG | Cemented Sand and Gravel |
| DEM | Digital Elevation Model |
| EIA | Environmental Impact Assessment |
| EIRR | Economic Internal Rate of Return |
| EL | Elevation |
| FFWS | Flood Forecasting and Warning System |
| F/S | Feasibility Study |
| GIS | Geographic Information System |
| GSM | Global System for Mobile Communication |
| IEE | Initial Environmental Examination |
| ISDN | Integrated Service Digital Network |
| MODEM | Modular-Demodular |
| NPV | Net Present Value |
| OCC | Opportunity Cost of Capital |
| ODA | Official Development Assistance |
| O/M | Operation and Maintenance |

| | |
|---|---|
| PRA | Participatory Rural Appraisal |
| PSTN | Public Switched Telephone Networks |
| RCRI | Radio Communication Regulatory of Iran |
| SPT | Standard Penetration Test |
| S/W | Scope of Work |
| TIN | Triangulated Irregular Network |
| VAT | Value Added Tax |
| VES | Vertical Electric Sounding |
| VHF | Very High Frequency |
| WLL | Wireless Local Loop |

## ABBREVIATIONS (MEASUREMENT UNIT)

| | | | |
|---|---|---|---|
| **Length** | | **Velocity** | |
| mm | millimeter | m/s | meter per second |
| cm | centimeter | **Sound Volume** | |
| m | meter | dB | decibel |
| km | kilometer | **Electric Power** | |
| **Area** | | V | volt |
| $m^2$ | square meter | **Time** | |
| $km^2$ | square kilometer | sec | second |
| ha | hectare | min | minute |
| **Volume** | | hr | hour |
| $m^3$ | cubic meter | yr | year |
| l, L | liter | **Currency** | |
| MCM | million cubic meter | IRR | Iranian Rial |
| **Flow Rate** | | JPY | Japanese Yen |
| $m^3$/s, CMS | cubic meter per second | USD | United States Dollar |
| **Weight** | | **Others** | |
| mg | milligram | % | percent |
| g | gram | ℃ | degree centigrade |
| kg | kilogram | $10^3$ | thousand |
| ton | metric ton | $10^6$ | million |
| | | $10^9$ | billion |

***FINAL REPORT (SUMMARY)***

***PAPER I***

***Master Plan***

# CHAPTER 1 INTRODUCTION

## 1.1 Background of the Study

The Caspian region, a northern part of the Islamic Republic of Iran including provinces of Gillan, Mazandaran and Golestan, has been frequently affected by the disasters of flood and debris flow. In the Madarsoo River basin, which is one of the disaster-affected areas in this region, about 260 people and 60 people were killed due to disasters of flood and debris flow during summer time in 2001 and 2002, respectively. Furthermore, thousands of livestock were lost and a lot of infrastructures, such as bridges and roads, were washed out or destroyed.

The Madarsoo River basin is located in the Golestan, North Khorasan and Semnan Provinces. It originates in the north side (the Caspian Sea side) of the Alborz Mountains running from the east to the west through the northern part of the country, and joins the Gorgan River that finally empties into the Caspian Sea. The Madarsoo River has a catchment area of 2,360 $km^2$ and a length of about 100 km. The population in the basin is about 60,000 people and the average annual rainfall is about 400 to 500 mm in this area. The road running paralleled to the river course is a part of important international corridor linked to neighboring countries, Turkmenistan and Afghanistan, and the sacred place of Shiite Muslim, Mashhad. The peak traffic density of the road is about 25,000 units/day.

In addition to the Madarsoo River basin, there are some river basins being composed of similar situations in hazardous topography and climate in the region. For instance about 50 people were killed by the disasters of flood and debris flow in the Nekka River basin in the Mazandaran Province, and the Maslee River basin in the Gillan Province is also under similar situation to these basins.

Under such vulnerable situations suffering from flood and debris hazards in the Caspian region, effective countermeasures have not been carried out yet. Furthermore the Government of the Islamic Republic of Iran (hereinafter referred to as “the Government of Iran”) has not formulated the master plan for disaster mitigation and management to rationalize and integrate various components of the structural and non-structural measures/schemes. Therefore formulation of the master plan in the Madarsoo river basin and transfer of technologies, which are based on the study/research experiences and technical standards for the similar basins, are urgently required in the Caspian region.

In response to the official request of the Government of Iran, the Japan International Cooperation Agency (hereinafter referred to as “JICA”) dispatched the preparatory study team, headed by Mr. Hara Yoshifumi, to Iran in the end of August 2003. After continuous discussion between the team and the Government of Iran, the both parties finally agreed upon the Scope of Work (hereinafter referred to as “S/W”) and the Minutes of Meetings for the better understandings of the S/W on 3rd September 2003.

Based on the S/W and the Minutes of Meetings, JICA decided to commence the captioned development study on “Flood and Debris Flow in the Caspian Coastal Area focusing on the Flood-hit Region in the Golestan Province in the Islamic Republic of Iran”, and to dispatch the study team to Iran in the end of October 2004.

## 1.2 Objectives of the Study

Objectives of the study are as follows:

1) To formulate a master plan up to the target year 2025 for prevention of flood and debris flow disaster in the Madarsoo River basin,

2) To select priority projects among the measures/schemes proposed in the above-mentioned master plan and to carry out the feasibility study on them,

3) To prepare technical manual and guidelines, containing planning and designing of flood and debris flow countermeasures, applicable not only to the Madarsoo basin but also to similar other basins in the Caspian coastal area, and

4) To pursue technology transfer to counterpart personnel in the course of the study, mainly focusing on planning and designing processes on flood and debris flow disaster mitigation and management.

Throughout the study to be conducted in accordance with the above objectives, the following overall goals will be realized in the study area:

1) The projects, which are proposed through the study, will be carried out and disaster of flood and debris flow will be mitigated, and

2) The Provincial Offices in the Caspian coastal area will conduct the proper planning and designing with necessary measures for flood and debris flow disaster mitigation and management.

## 1.3 Study Area

The study area is mainly the Madarsoo River basin of the Golestan Province with a drainage area of about 2,300 km$^2$. In addition the other similar river basins in the Caspian coastal area shall be covered in the study, for instance the Nekka River basin of the Mazandaran Province and the Maslee River basin of the Gillan Province.

## 1.4 Work Schedule

Fig. PI.1 shows a work schedule of the study. The study started in the middle of October 2004 in a manner of Home Work. Then the field survey in Iran started at the end of October and it will continue until the beginning of September 2006.

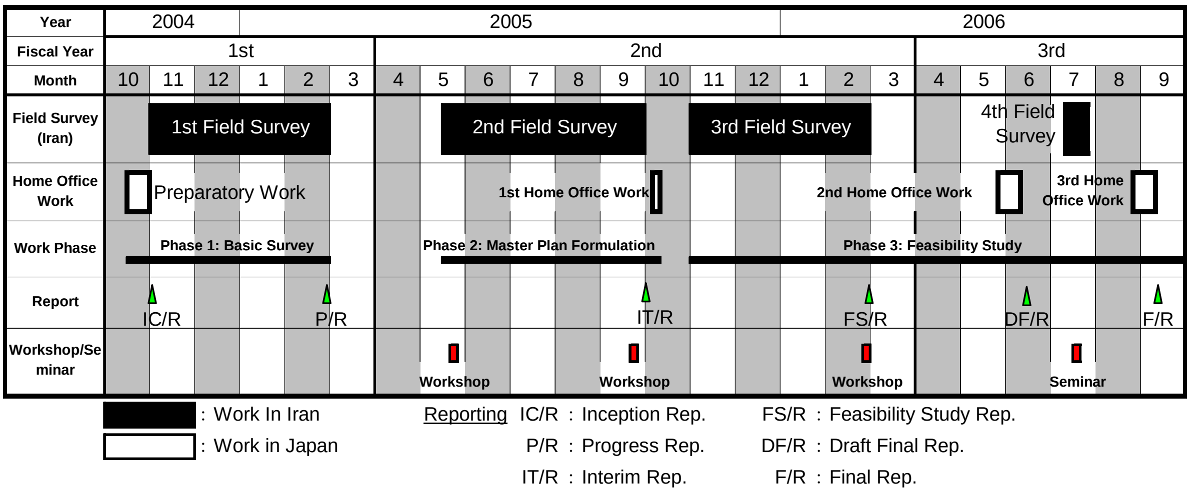


**Fig. PI.1 Work Schedule of the Study**

# CHAPTER 2 PRESENT CONDITIONS OF THE STUDY AREA AND ANALYSIS

## 2.1 Basin Physical Features

### 2.1.1 Geographical and Morphological Features

<u>Geographical Feature</u>

The Madarsoo River basin is defined as a river system connecting to the Gorgan River at Garkar, Minudash, Golestan Province with a main stream originated from the mountain range in Nardein, Semnan Province passing through Dasht, Khorasan Province. In addition, Chesmeh Khan River, one of the tributaries expanding the river basin eastward, meets the main stream downstream of Dasht village. The whole area of the river basin is 2,340 km$^2$ and located between around 55° 21´ and 56° 28´ in east longitude, and around 36° 58´ and 37 ° 30´ in north latitude respectively.

The features of the river basin could be divided into eight sub-basins, which had prominent characteristics in meteorological and topographical aspects. They are; (1) Nardein-Gelman Darreh, (2) Cheshmeh Khan, (3) Dasht-e-Sheikh, (4) Ghyz Ghaleh, (5) Golestan Forest, (6) Tangrah and 14 Metry bridge, (7) Agh Soo and (8) Lower reaches.

Basin divide is shown in Fig. PI.2.

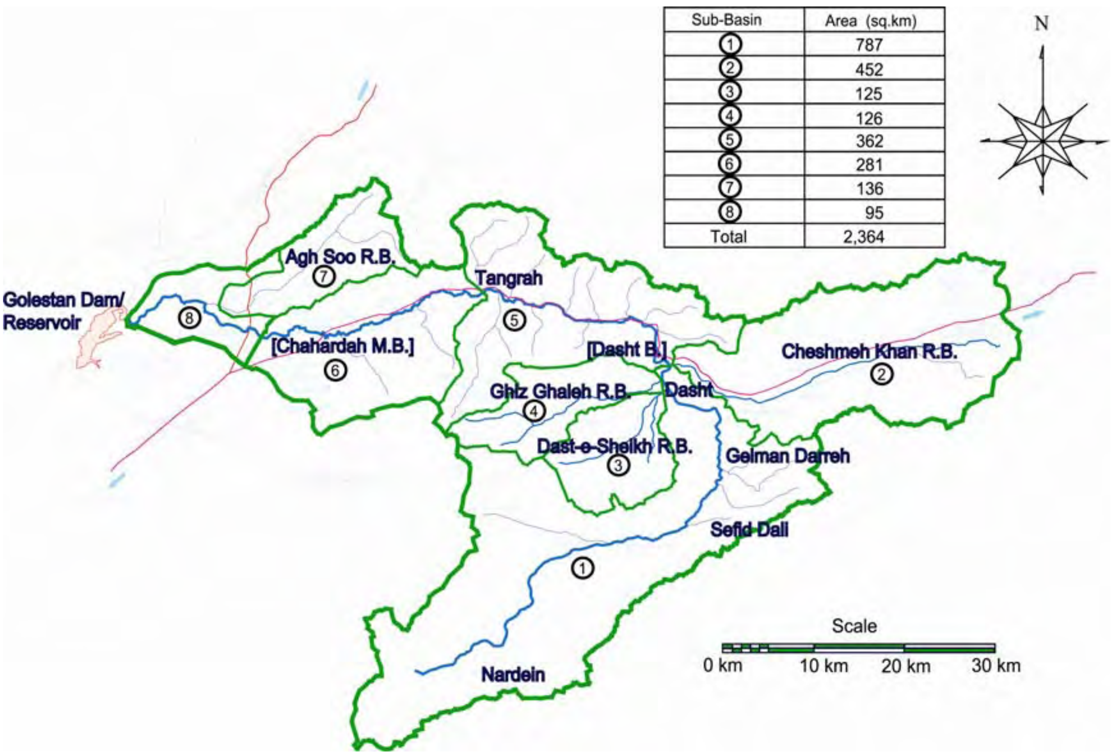


**Fig. PI.2 Madarsoo River and Basin Divide**

<u>River Morphological Feature</u>

Riverbed longitudinal profile of the main stream taken from topographic maps with a scale of 1/50,000 is around 142 km in lenghth and 1.4 % in average slope. The riverbed slope consists of 4.8 % in mountain side of Nardein, 0.6 % in Nardein-Sefid Dali plain, 1.2 % from Sefid Dali to Dasht Bridge, 1.9 % in Golestan Forest from Dasht bridge to Tangrah, and 1.1 to 0.7 % from Tangrah to the Golestan Dam Reservoir in average slope. They are shown in Fig. PI.3.

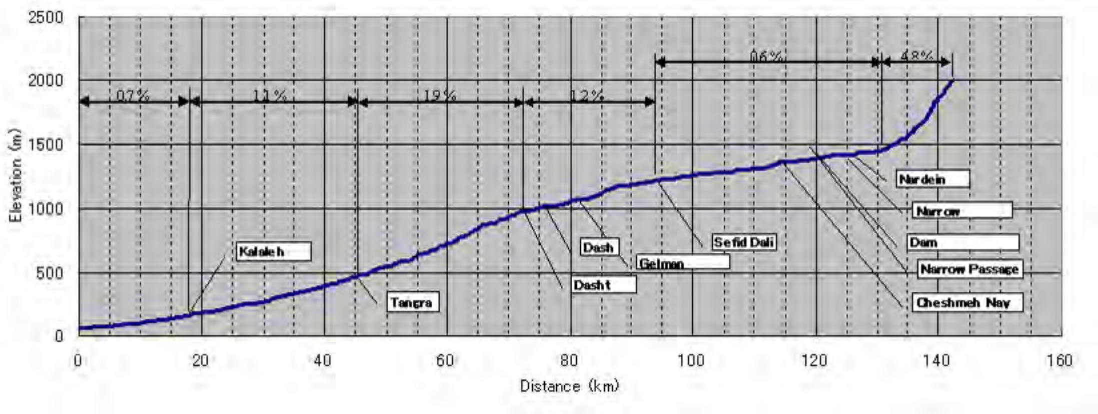


**Fig. PI.3 Riverbed Longitudinal Profile of the Madarsoo Main Stream**

### 2.1.2 Topography and Geology

Topography

The main regional topography in the study area is summarized below. Slope distribution over the basin is presented in Fig. PI.4.

(1) Alluvial Plain to Inundation Region

The Alluvial plain and inundation area are evidenced by a flat feature with a regular seaward slope and widely distributed in Nardein basin with an elevation of about 1,415-1,430 m, Cheshmeh Nay to Sefid Daly basin with 1,300–1,400 m, Cheshmeh Khan to Robat Gharabil basin with 1,200 – 1,500 m, Dasht basin with 1,000–1,200 m, and downstream reaches of Tangrah with 65–500 m.

It consists of various topographical elements of riverbed, floodplain, fan, and natural levee. This region has been widely utilizing for farming.

(2) Hilly Region

Hilly region extends between alluvial plain to mountainous region, and at the middle western part of drainage border near Sudaran, Goldin, Kolanke and Dastshad villages, and locally here and there where talus deposit, Tertiary formation, and heavily weathered rocks are distributed.

This topography is characterized as a gentle and smooth relief on river terrace and old age topography. The drainage pattern is parallel and it forms a gentle valley with a riverbed gradient of 1/10 to 1/20. Gully erosion is dominant in this region because of soft or fragile characteristics of these rocks. This region has been utilizing for dry farming and grazing.

(3) Mountainous Region

It is distributed mainly in the middle stream reaches from Dasht village to Terjenly village with an elevation of about 500 m in the riverbed to the border of the study area with an elevation of about 1,700 to 2,300 m. It shows rugged and very steep slope with cliff in the distribution area of Cretaceous limestone. Small traces of collapse are distributed here and there.

The drainage pattern is dendritic and it forms a steep to very steep valley. The vegetation coverage is generally low excluding the Golestan National Park, especially in the headwaters of Nardein and Robat Gharabil basins.

The Golestan National Park is located in the middle reaches of the Madarsoo River with rich natural forests.

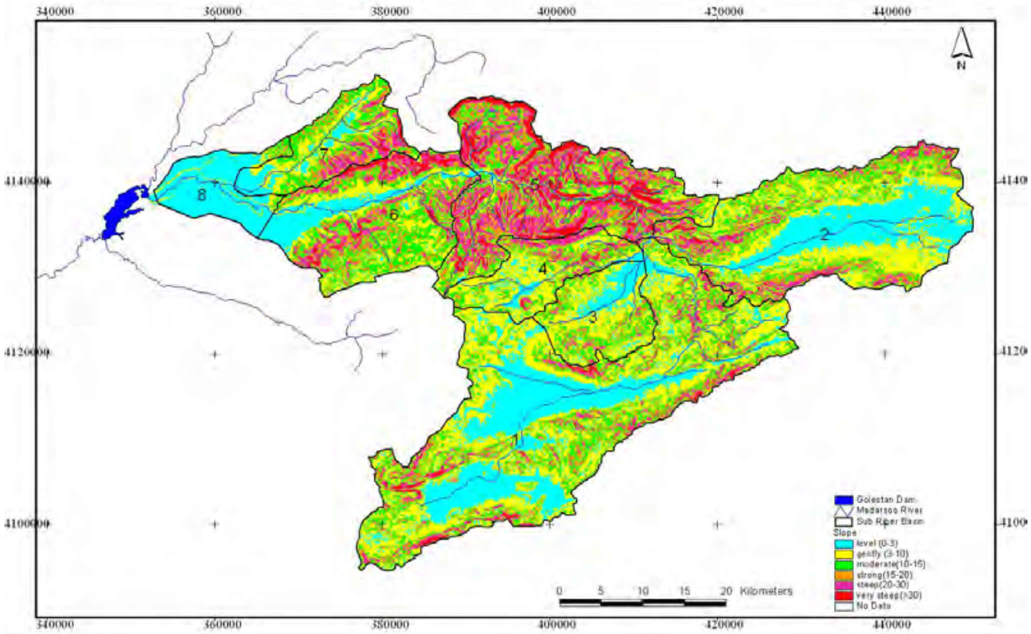


**Fig. PI.4 Slope Distribution**

Geology

The study area is located in the Alborz Mountains that is the continuum of Anatolia Mountains in Turkey that is characterized by seismic activities.

The study area is also located in the transition zoon of East Albolz Tectonic Zone and Koppeh Dagh Tectonic Zone. These two tectonic zones meet around from Tangrah village to Robat Gharabil village.  Proterozoic to present sedimentary rocks are distributed with a few igneous rocks in the study area and they are heavily folded and faulted. These basement rocks are covered by Quaternary deposit of river, talus, terrace, fan, and loess. The Quaternary deposits are widely distributed in the Nardein-Sefid Dali basin, Cheshmeh Khan basin, Dasht-e-Sheikh basin, Ghiz Ghaleh basin, and the lower reaches of the Madarsoo River (refer to Fig. PI.5).

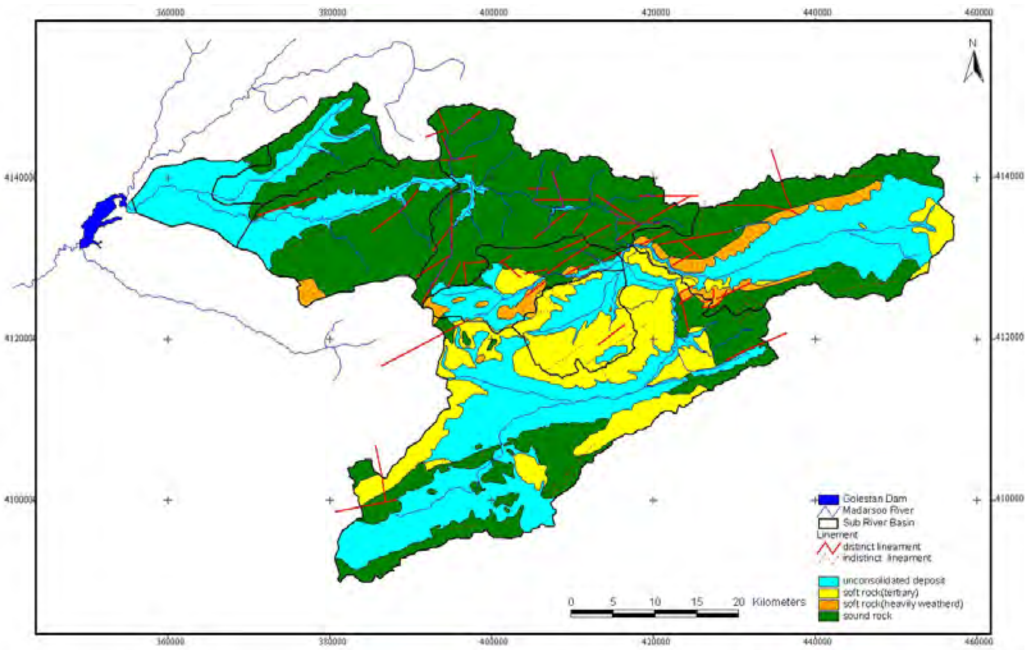


**Fig. PI.5  Engineering Geological Map**

### 2.1.3 Meteorology

Climate

The study area, Madarsoo River basin, is stretch in-between longitude 55° 21' to 56° 28' E and latitude 36° 58' to 37° 30' N. Rainfall distribution patterns in the basin were analyzed. Study shows semi-arid type of climate is prevalent in the basin. The monthly and annual rainfalls amounts at stations in the basin are quite variable. For instance, annual rainfalls are: 695 mm (Tangrah), 357 mm (Dasht Shad) and 198 mm (Robat Gharebil). Similarly, monthly rainfalls in March are: 99 mm (Tangrah), 45 mm (Dasht Shad) and 30 mm (Robat Gharebil). March is the highest rainfall month in the basin. After analyzing the annual and monthly rainfalls at stations in the basin; it shows that November to May are wet months; and June to October are dry months (Fig. PI.6). As usual, convectional, orographic, cyclonic and monsoon rains occur in the basin.

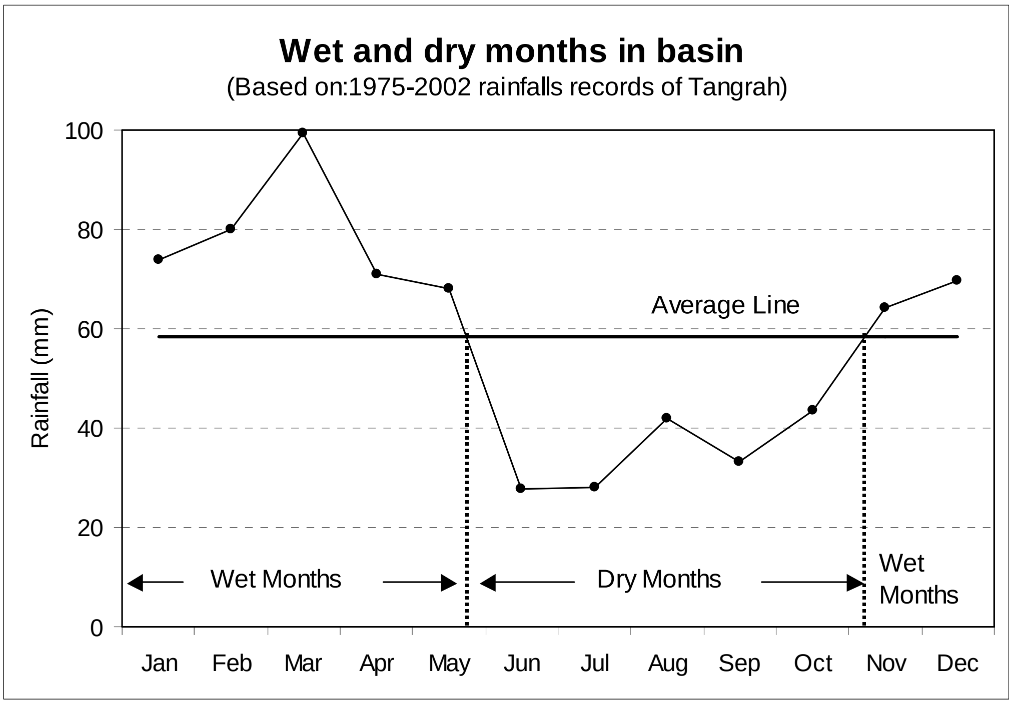


**Fig. PI.6 Wet and Dry Months in the Madarsoo Basin**

Weather Conditions during the 2001 and 2002 Floods

The meteorological parameters like rainfall, relative humidity (RH), air temperature, and wind speed at various stations in the basin were analyzed on the day of flood and a day before during the 2001 and 2002 floods. Weather conditions in those floods are described below focusing on daily rainfall.

Daily rainfall isohyets in the 2001 and 2002 Floods were developed. There was considerable amount of rainfall (50 mm) only at Dasht Kalpoush on previous day (10 August) of the 2001 Flood in the basin. However, on the day of the flood (11 August), heavy rainfall occurred at Dasht Shad (176 mm), Tangrah (150 mm), Soodaghlene (117 mm), Dasht Kalpoush (100 mm) and Chesmeh Khan (84 mm) as present in isohyets (Fig. PI.7). Rainfall isohyets of the flood day show that 80-176 mm rainfall occurred on about 50 % of basin area at central part of the basin (with peak rainfall at Dasht Shad). In other areas of the basin, amount of rain was in-between 20–80 mm on the flood day. It has been said that high intensity rain has occurred for sometime which caused the 2001 disastrous flood. The intensity of rainfall could not be analyzed due to not having hourly rainfall data of the stations. Moreover, flood hydrograph of the Madarsoo River at Tangrah also indicates possibility of high intensity rain occurrence in the basin during the 2001 Flood, because flood hydrograph is rising sharply.

Similarly, debris flow and gully formation at Terjenly also indicates possibility of high intensity rain occurrence during the flood.

During the 2002 Flood, on previous day of the flood (12 August) there was 24 mm rainfall at Tangrah but no rainfall at other stations in the basin. But on the day of the flood (13 August), heavy rainfall occurred at Dasht Shad (108 mm) and Dasht Kalpoush (60 mm). Furthermore, considerable amount of rainfalls occurred at other stations like Soodaghlene (33.4 mm), Nardin (25 mm), Chesmeh Khan (16 mm) and Tangrah (30 mm). The rainfalls distribution in the basin on the day of flood is presented by isohyets (Fig. PI.8). Rainfall isohyets of the flood day show that there was 40–108 mm rain on about 35 % of basin area at central part of the basin (with peak rainfall at Dasht Shad). In other parts of the basin, only 10–40 mm rainfall occurred on the day of the flood.

<u>Spatial Distribution of Rain during the 2005 Flood</u>

The point rainfall data at different stations in the basin on the day of the flood (10 August) and on one day before the flood (09 August) were collected. There was no rainfall at any stations in the basin on one day before the flood. But, on the day of the flood heavy rainfall occurred over the basin. The point rainfall amounts in and around the basin on the day of flood (10 August) were: 14 mm (Tilabad), 12 mm (Nardin), 110 mm (Soodaghlene), 113 mm (Dasht Shad), 98 mm (Dasht), 137 mm (Tangrah), 33 mm (Pishkamar), 7 mm (Galikesh), 85 mm (Chesmeh Khan) and 17.5 mm (Robat Gharebil). The spatial distribution of rain over the basin on the day of the flood is presented by developing rainfall isohyets (Fig. PI.9). It shows that 80–137 mm of rainfall occurred on about 55 % of basin area.

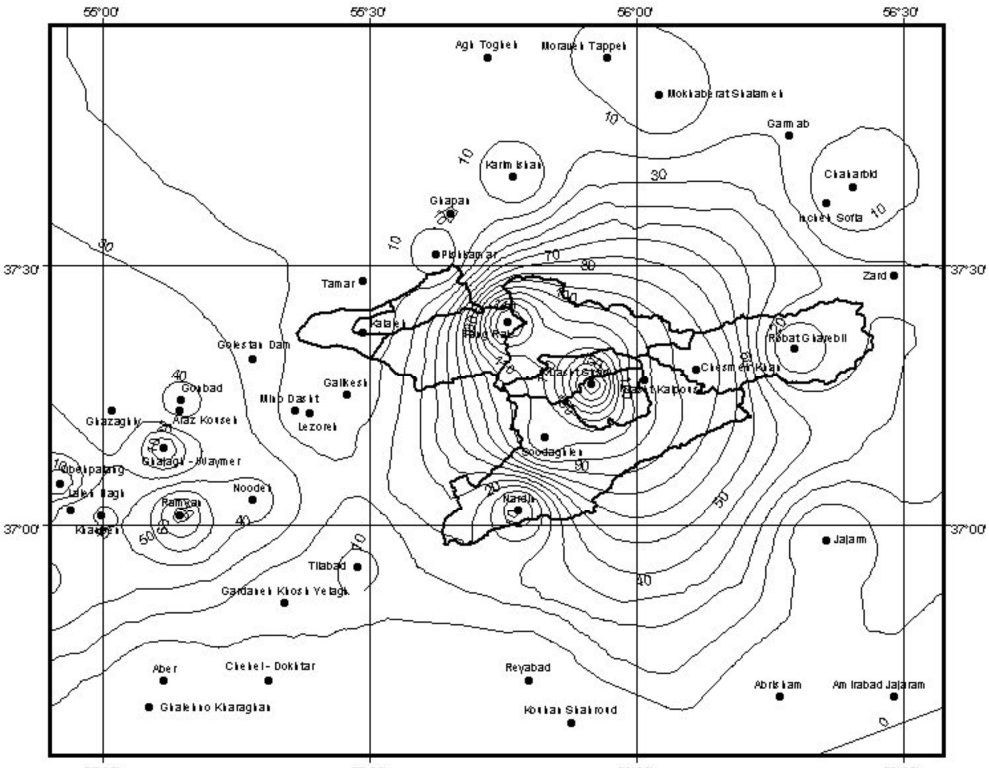


**Fig. PI.7  Rainfall Isohyets (11 August 2001)**

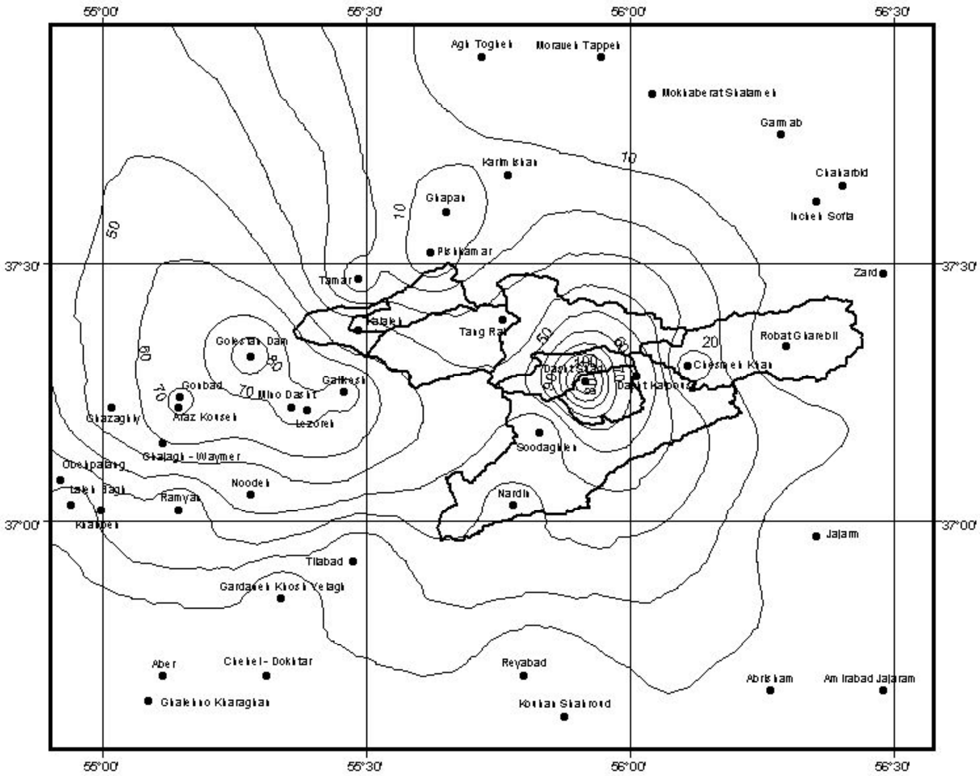


**Fig. PI.8 Rainfall Isohyets (13 August 2002)**

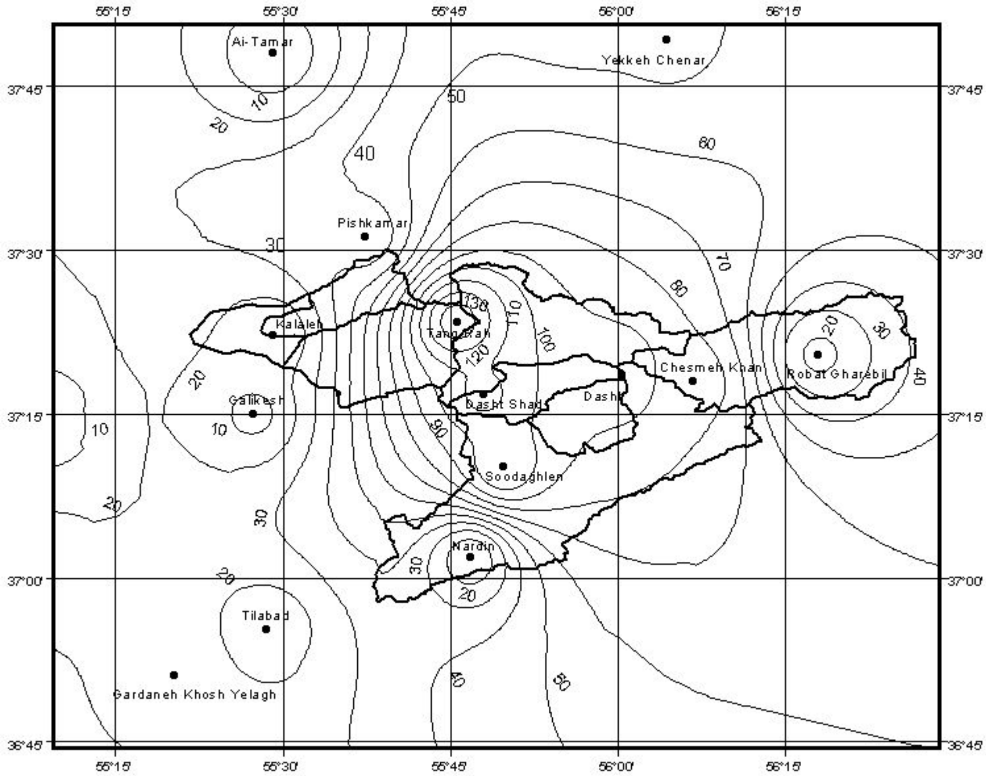


**Fig. PI.9 Rainfall Isohyets (10 August 2005)**

<u>Monthly and Annual Rainfall Distribution</u>

Monthly rainfall distribution in the basin shows March is the highest rainfall month. In this month, over the lower to middle part of the Madarsoo river basin (Golestan Dam to Tangrah), 80-99 mm rainfall occurs. The amount of rain decreases as going to the middle part from the lower part of the basin (from Golestan Dam to Tangrah). The isohyets show on the upper (Nardin and Robat Gharebil) to middle (Tangrah) part of the basin 20-99 mm rain occurs in March. The amount of rain increases as going to the middle part from the upper-most parts of the basin. Furthermore, annual rainfall isohyets indicate Tangrah and its vicinity get the highest rainfalls in the basin (Fig. PI.10). Annual rainfall at the lower-most part of the basin is 500 mm and amount gradually increases as going to the middle part of the basin and reaches 695 mm at Tangrah. As going further upstream part of the basin from Tangrah, then annual rainfall amount declines and reaches up to 198 mm (Robat Gharebil) and 139 mm (Dasht Kalpoush).

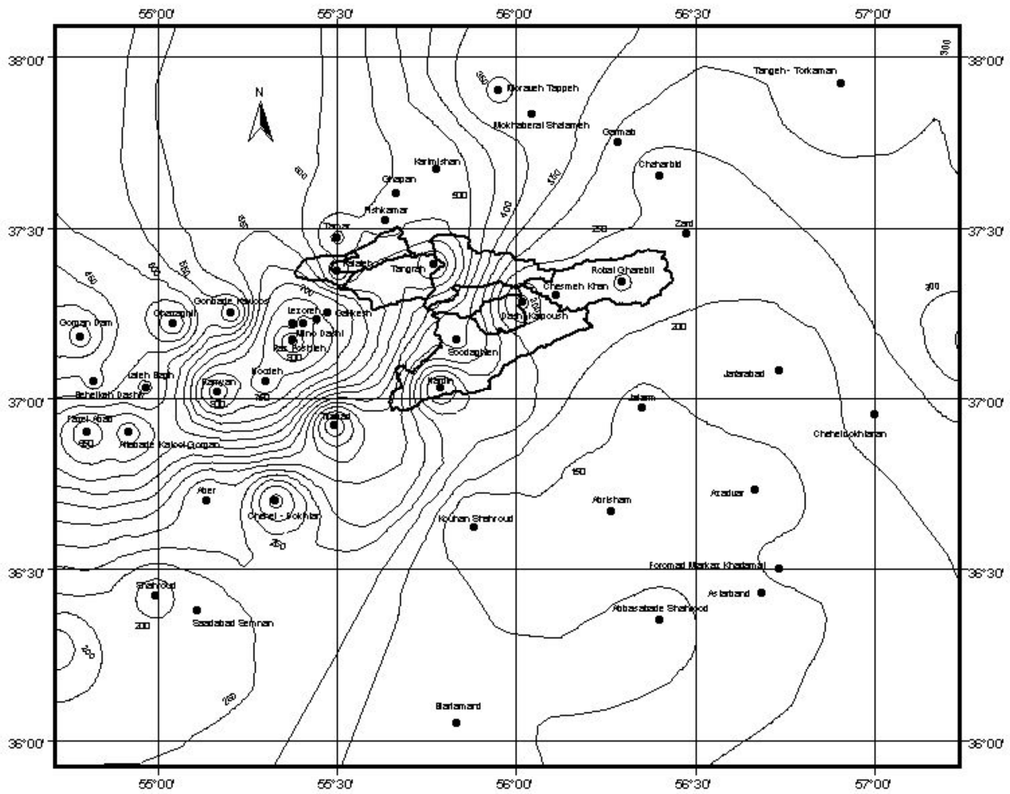


**Fig. PI.10 Annual Rainfall Isohyets**

## 2.2 Basin Socio-Economic Features

### 2.2.1 Socio-Economic Profile

<u>Socio-Economic Profile in Iran</u>

(1) Demography

Iran's total population is estimated at 66.4 million and its growth rate is 1.5 % in 2003 according to the World Bank. Iran has the second largest population, after Egypt, in the Middle East and North Africa region. The census data of Iran shows that the average annual growth rate has been decreasing with the exception in 1986. The exception may be attributed to the Iran-Iraq War, which was continued over 1986.

(2) Other Social Indicators

Following social indicators shows preferable profiles of Iran with the comparison of other Middle East and North African Countries: life expectancy, infant mortality, access to an improved water source and gross primary education enrolment. In addition almost all of them are better than the average of lower to middle income counties. The World Bank's Country Brief, September 2004 describes that Iran's health and education indicators are the best in the region. Furthermore, lager numbers of increasingly well-educated women seek opportunities to participate all levels of Iran's labor market and civil society. This is another side of the successful social policy of Iran. It is a new challenge for the Government to cope with in order to manage a stable economy and society.

**Table PI.1 Major Social Indicators of Iran**

| | Iran | Middle East & North Africa | Lower-middle Income |
|---|---|---|---|
| Ave. Annual Growth (1997-2003) | | | |
| Population (%) | 1.5 | 1.9 | 0.9 |
| Labor force (%) | 2.9 | 2.9 | 1.2 |
| Most recent estimate (latest year available, 1997-2003) | | | |
| Poverty (%of population below national poverty level) | 21 | - | - |
| Urban population (% of total population) | 67 | 58 | 50 |
| Life expectancy at birth (years) | 71 | 69 | 69 |
| Infant mortality (per 1,000 live birth) | 30 | 44 | 32 |
| Child malnutrition (% of children under 5) | 11 | - | 11 |
| Access to an improved water source (% of population) | 99 | 88 | 81 |
| Illiteracy (% of population age 15+) | 15 | 31 | 10 |
| Gross primary education enrolment (% of school-age population) | 98 | 96 | 112 |
| Male | 102 | 100 | 113 |
| Female | 95 | 92 | 111 |

Source: World Bank

<u>Socio-Economic Profile in Golestan Province</u>

(1) Demography

Population growth shows different trend between the rural area and urban area. The growth rate of the urban area had been decreasing continuously while that of rural area had fluctuated in the past. As it is shown in the national data, even the rural area implies some declining trend if we consider the 1986 data is an exception. The 1976 data is 1.45 % and the 1996 data is 1.43 % when the further decimal digit is calculated. In addition, it should be noted that the urban growth rates are generally higher than the rural rates.

Concerning the average number of family members that of urban area has the trend of decreasing except 1986 while that of rural area has the trend of increasing. It is noticeable that the number is higher in urban area than in rural area in early years and the figures had reversed from 1976. With an assumption that urbanization reduces the number, the urbanization in the "urban area" started in 1970s. On the other hand, the agricultural production of household has been feeding more and more family members in the rural area.

(2) Other Socio-Economic Indicators

Golestan Province can be generally ranked at the middle of all 28 Province/Administrative Divisions. Its agricultural production such as wheat is ranked at a higher level. It is noticeable that the number of medical beds per 100,000 populations is ranked at the lowest level.

**Table PI.2 Socio-Economic Indicators**

| | Area (sq km) | Rank | Population in 1996 | Rank | Average Production of Wheat 2000-01 (1,000 tons) | Rank | Manufacturing Establishments with 10 or More Workers in 2000 | Rank | Number of Medical Beds per 100,000 in 2001 | Rank | Government Budget (Current + Development) in 2000 | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golestan | 20,893 | 19 | 1,426,288 | 15 | 723 | 4 | 159 | 17 | 115 | 27 | 667,861 | 16 |
| Tehran | 19,196 | 22 | 10,343,965 | 1 | 194 | 15 | 2,716 | 1 | 279 | 1 | 3,203,868 | 1 |
| Iran Total | 1,629,805 | | 60,055,488 | | 9,458 | | 11,200 | | 182 | | 26,850,497 | |

Source: Iran Statistical Year Book, 2001

## 2.2.2 Socio-Economic Frame Forecast

GDP Growth

Comparative study was made to determine the GDP growth rate for future projection. The following two methodologies are compared: (a) GDP projection using actual past trend and (b) GDP projection modified by the World Bank forecast.

According to the actual data reported in the statistics, the growth rate of GDP in 2002 is 7.83 %. On the other hand, the annual average growth rates, which were forecasted by the World Bank, are 7.4 % in 2002, 6.6 % in 2003 and 5.7 % from 2003 to 2007. The growth rate of 7.4 % in 2002 forecasted by the World Bank is lower than the actual one, and it may be on account of temporary data applied.

The annual average growth rate of (a) GDP based on the actual past trend is employed at 8.43 % since 2003 till 2025. It seems rather optimistic comparing with the World Bank forecast. Accordingly, the other forecast is made based on the World Bank forecast as shown in the following figure.

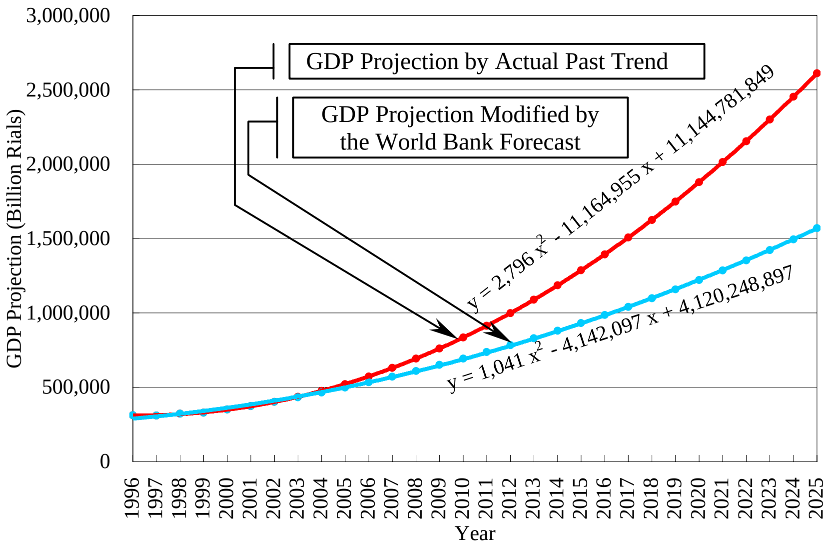


**Fig. PI.11 GDP Projection Based on Actual Trend Modified by the World Bank Forecast**

Using the formula showing in the above figure of GDP projection modified by the World Bank forecast, the other annual amount of GDP can be estimated for the future as shown in the following table.

**Table PI.3 GDP Projection Based on Actual Past Trend Modified by World Bank Forecast in 1997 Constant Price**

(GDP in Total: Billion Rials)

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP in Total | 312,531 | 311,123 | 322,701 | 329,103 | 350,910 | 372,685 | 401,874 | 432,587 | 464,861 | 498,726 |
| Growth Rate against Previous Year | | -0.45% | 3.72% | 1.98% | 6.63% | 6.21% | 7.83% | 7.64% | 7.46% | 7.29% |

| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP in Total | 534,211 | 571,348 | 610,164 | 650,691 | 692,962 | 737,010 | 782,872 | 830,587 | 880,197 | 931,751 |
| Growth Rate against Previous Year | 7.12% | 6.95% | 6.79% | 6.64% | 6.50% | 6.36% | 6.22% | 6.09% | 5.97% | 5.86% |

| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP in Total | 985,300 | 1,040,903 | 1,098,625 | 1,158,537 | 1,220,720 | 1,285,264 | 1,352,269 | 1,421,848 | 1,494,125 | 1,569,237 |
| Growth Rate against Previous Year | 5.75% | 5.64% | 5.55% | 5.45% | 5.37% | 5.29% | 5.21% | 5.15% | 5.08% | 5.03% |

Sourse: Data from 1996 to 2002 is excerpted from the Iran Statistical Year bBook 1382.

Population

(1) Present Population

Total present population (2005) of the study area is 93,141, of which 46,882 (50.3 %) live in flood-prone area, and 46,259 (49.7 %) live in the other areas. Flood-prone area encompasses villages, which are usually affected by flood/debris flow, and were thoroughly covered by the JICA survey for Environmental and Social Considerations conducted during October 2004 to June 2005.

(2) Future Population

Since the target year of the master plan is 2025, population for target year is estimated with 5-year interval, to provide ground for design and establishment of infrastructures/institutions to meet future demand of the area. In estimating future population, following relation has been applied:

$$Fp = Pp \times (1+pgr)^n$$

Where *Fp* is future population; *Pp* present population; *1* is constant number; *pgr* is average annual population growth rate in %, and *n* is interval of years.

Here population is estimated for the next 20 years with 5-year interval, so $n = 5$, and average annual growth rate is set at 1.80 %, assuming all factors on population growth remain constant.

Bases/reference for applying the figure 1.80 % growth rate in this formula:

- Average of long-term of annual population growth rate in Golestan province is 1.72 % (2.30 % in urban area and 1.14 % in rural area). Since the study area is comprised of urban and rural areas and largely occurs in Golestan, figure of 1.72 % can be used for estimating its future population.

- Result of statistical analysis performed by Iranian consultants working for MOJA in the Madarsoo River basin, indicates that growth rate of 1.80 % is reasonable in predicting population of this area. They have applied the same figure in their calculations.
- Average annual growth rate of population for the country (on long-term basis) is 1.80 %, with decreasing trend.

It should be noted that with introduction/encouragement of family planning schemes by the Iranian government, and prevalence of old motto "less child, better life", population growth rate would keep its constant trend, or even show decreasing tendency in future. Therefore data on population growth presented in this report can be reliably used in development plans.

**Table PI.4 Present and Future Population in the Madarsoo River Basin**

| Area | Present | Future | | | |
|---|---|---|---|---|---|
| | 2005 | 2010 | 2015 | 2020 | 2025 |
| Flood Prone | 46,882 | 51,256 | 56,038 | 61,266 | 66,982 |
| Others | 46,259 | 50,575 | 55,294 | 60,453 | 66,093 |
| Overall | 93,141 | 101,831 | 111,332 | 121,719 | 133,075 |
| Population Density (Persons/ha) | 0.39 | 0.43 | 0.47 | 0.51 | 0.56 |

Total area (flood prone + others) 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

### 2.2.3 Land Use

Past Land Use

Data for land use in 1960s indicates that larger areas have been under rangeland and forest, and lesser areas under irrigated and dry farming (Table PI.5). This could be attributed to lower population, and biological densities in the area, and thus less pressure on natural resources. Area of bare land was significantly high, indicating less competition for land occupation, and more choices in selecting favorable location for economic activities. Large area of forest occurred in territory of Golestan province, while rangelands were distributed mostly in Khorasan and Semnan province. Irrigated farming was mainly practiced in lower reaches of the Madarsoo River basin in the plains of Golestan province.

**Table PI.5 Past (1960s) Land Use in the Madarsoo River Basin**

| Land Use | Area (ha) | % of Total |
|---|---|---|
| Afforestation | 1,814 | 0.77 |
| Bare Lands | 5,502 | 2.33 |
| Desert | 1,067 | 0.45 |
| Dry Farming | 30,748 | 13.01 |
| Forest | 67,473 | 28.54 |
| Irrigated Farming | 14,865 | 6.29 |
| Lake | 115 | 0.05 |
| Rangeland | 114,552 | 48.45 |
| Mixed Dry Farming and Rangeland | 10 | 0.00 |
| Residential (Urban) | 254 | 0.11 |
| Others (limits of sites for structures, roads, observatory stations, etc) | - | - |
| Total | 236,400 | 100.00 |

*Source:* Ministry of Jihad-e-Agriculture (MOJA), GIS Division.

Present Land Use

Present land use map (2005) was prepared based on the latest (2002) satellite imagery of the area, checked through the field survey and revised based on experience and knowledge of the MOJA experts, with collaboration of the study team. Final output of this work is presented in Table PI.6 as well as Fig. PI.12.

**Table PI.6 Present (2005) Land Use in the Madarsoo River Basin**

| Land Use | Area (ha) | % of Total |
|---|---|---|
| Afforestation | 1,830 | 0.77 |
| Bare Lands | 2,693 | 1.14 |
| Desert | 1,078 | 0.46 |
| Dry Farming | 39,276 | 16.61 |
| Forest | 64,781 | 27.40 |
| Irrigated Farming | 30,703 | 12.99 |
| Lake | 126 | 0.05 |
| Rangeland | 94,709 | 40.06 |
| Mixed Dry Farming and Rangeland | 938 | 0.41 |
| Residential (Urban) | 266 | 0.11 |
| Others (limits of sites for structures, roads, observatory stations, etc) | - | - |
| Total | 236,400 | 100.00 |

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

Future Land Use

The future land use plan is formulated as tabulated in Table PI.7, paying attention to following points:

(1) No chronic changes in land use during the past decades by examining relevant documents and materials

(2) Predicting the future population till target year of 2025

(3) Realizing the biological capability and environmental condition of the area

(4) Paying attention to concept of sustainable development and wise/efficient utilization of natural resources

(5) Avoiding any harm to national natural reserves or historical/cultural heritages

(6) The plan is a back to future approach, means attempt is made to bring the status of natural resources more or less near to that of 1960s, which reflects the biological capability of the area on that period. In planning biological capability should be highly considered.

(7) Emphasizing on crop yield increment in existing irrigated fields by enhancing water use efficiency and improvement in farm practice, rather area expansion

**Table PI.7 Future (2025) Land use in the Madarsoo River Basin**

| 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.

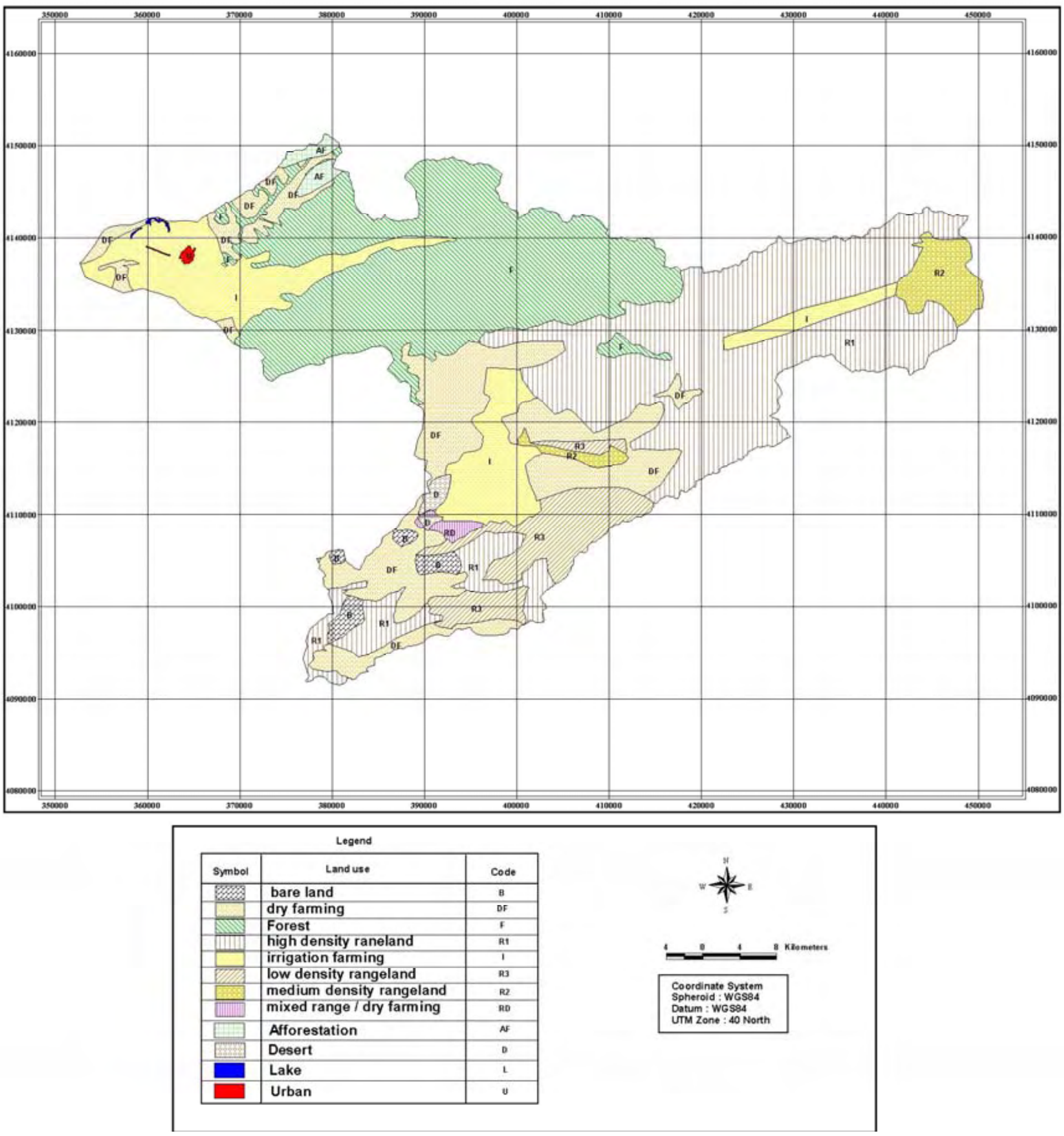


**Fig. PI.12 Present Land Use Map in 2005**

## 2.3 Flood Disaster

### 2.3.1 Flood Damage and Causes of Casualty

Caspian Sea region in the northern part of the Islamic Republic of Iran includes provinces of Gillan, Mazandaran and Golestan, is subjected to frequent disasters of flood and debris flow. Madarsoo River basin is one of the disaster-prone basins in this region, which suffered huge damages as consequences of two big floods occurred in the years of 2001 and 2002. Some of these damages are tabulated below to reflect the severity of flood damages. It should be noted that the figures in this table indicate only physical/economic loses, but not deal with psychological and emotional stresses imposed on people by the floods.

**Table PI.8 Flood Damage in 2001 and 2002**

| Type of Damage | Damage in 2001 | Damage in 2002 |
|---|---|---|
| Road demolished | 194 km | 182 km |
| Farms and orchards demolished | 15,000 ha | 400 ha |
| People wounded | 200 people | 5 people |
| People killed and missing | 254 people | 54 people |
| Livestock lost | 6,000 heads | 1,000 heads |
| Forest demolished | 5,500 ha | - |
| Rangeland demolished | 10,000 ha | 10,000 ha |
| Vehicles destroyed | 130 units | 9 units |
| Residential/business building demolished | 3,000 units | 1,810 units |
| Telephone office demolished | 7 units | 5 units |
| Estimated Economic Damages | 580 billion Rials | 213 billion Rials |

The historical floods always occurred in August, when it is summer tourism season in Iran, and numerous visitors and campers visit to the Golestan Forest Park along the mainstream of the Madarsoo. The floods and debris flow, suddenly occurred due to intensive downpour, had carried off lots of visitors and campers as well as residents in the villages along the Madarsoo River.

As presented in the following table, more than 70 % of casualties were visitors and campers in the Golestan Forest in the 2001 Flood. Similarly more than 80 % of casualties were the visitors and campers in the 2002 Flood. In contrast, although various infrastructures of roads, bridges and riverbank walls, which had been rehabilitated or under rehabilitation, were completely destroyed in the 2005 Flood, there were no casualties. This might be a good learning effect by the government officials and residents living nearby the river course after the above-mentioned two floods. Before the flood coming, the visitors and campers were evacuated out of the Forest Park area, based on the weather forecast warned by the MET-Golestan Office.

**Table PI.9 Causal Relationship of Flood Casualty**

| Cases of Casualty/Places | Casualties | | |
|---|---|---|---|
| | 2001 Flood | 2002 Flood | 2005 Flood |
| Rolling-down incident to the mainstream in Dasht village | 26 | - | - |
| Camping sites in the Golestan Forest | 194 | 44 | - |
| Debris avalanche in Terjenly village | 3 | - | - |
| Bank erosion in Loveh village | 24 | - | - |
| Rolling-down incident to the mainstream in the middle stretch | 7 | 6 | - |
| Others (workers for road rehabilitation) | - | 4 | - |
| Total | 254 | 54 | 0 |

The above table implies the following useful information to deliberate upon the effective direction of the flood mitigation and management. These are facts experienced in the 2001 Flood.

- 26 villagers had been evacuating from Dasht village along the river course by tractor, and rolled down to the turbulent floodwater of the mainstream. If some proper information on necessary action and appropriate evacuation route had been given to the villagers, the incident would not happened.
- Since narrow and steep gorge with 60 to 200 m wide is formed along the mainstream in the Golestan Forest, the visitors and campers cannot escape from the riverside to some safer places while the swollen floodwater passed in the Forest accompanying with upsurge of water level. They had no other choice of being washed out by the turbulent floodwater.
- Camping sites in the Golestan Forest were located on the previous debris flow deposits due to flat topography, so that the debris avalanche occurring in the mountain stream washed out the campers staying the sites.
- In Terjenly village, two children climbed a tree alongside a mountain stream for evacuation, and their mother ran after them. Finally the tree fell down into the debris flow with three people. This process also reveals the incident to be avoided if the necessary information was provided to the villagers beforehand.
- In Loveh village, turbulent floodwater eroded the riverbank where the residential houses were situated, and the villagers sleeping deeply died due to collapse of their houses into the floodwater.
- In contrast, in Beshoily village located 5 km upstream of Loveh village, some villager got a scent of impending danger due to approaching extraordinary sound like jet plain, and announced warning message to the villagers. Immediately after receiving his warning, all villagers evacuated to the backside mountain, and finally there were no casualties in the village although most of the residential houses were completely destroyed by the floodwater.
- A few residents in the middle reaches died in both floods in 2001 and 2002. They were farmers, shepherds and housewife who went to the riverside and incidentally rolled down into the turbulent floodwater. If some proper information on danger of floodwater had been given to the residents, these incidents would not happened.

These facts on causes of casualty imply that most of the casualties in the 2001 and 2002 Floods could be saved from their death if early warning and proper evacuation order were disseminated beforehand and knowledge building on disaster management had been made as a routine basis to the residents.

### 2.3.2 Causes of Flood Disaster

Regarding the causes of flood disaster in 2001, various discussions were made after the 2001 flood disaster. Major issues raised are deterioration of watershed and illegal or excessive logging in the mountainous areas. Through data collection and hydrological analysis, however, the major causes of 2001 flood disaster are clarified as 1) occurrence of historical heavy rainfall and 2) occurrence of debris flow in various mountain streams in parallel with large flood in the mainstream. These are briefly described below, using related data in both floods, 2001 and 2005.

<u>Rainfall</u>

Rainfall started on 10 August 2001, and reached to the peak on the next day, 11 August. Daily rainfall aggregated to 150 to 180 mm in the Golestan Forest Park as already presented in Fig. PI.7.

On the other hand, the 2005 Flood was the first flood that hourly rainfall could be observed in the Madarsoo River basin. After the 2001 Flood, Met-Golestan and MOE each installed online rainfall stations. Among four stations, only Tangrah station, where most intensive rainfall always occurred, recorded hourly rainfall. Another stations could not recorded hourly rainfall due to malfunctioning of recorder or data logger.

In the 2005 Flood, the peak of rainfall appears on 10 August, and daily rainfall aggregated to 100 to 130 mm centering on the Golestan Forest as already shown in Fig. PI.9. Tangrah station recorded hourly rainfall of 80 mm/hr so that it verified occurrence of intensive downpour in a short duration.

Flood Discharge

Flood hydrographs observed or estimated for the 2001 and 2005 Floods and hydrological modeling are discussed in the succeeding section 2.4. Based on the simulation results, the peak discharges in both floods are illustrated in the following figure.

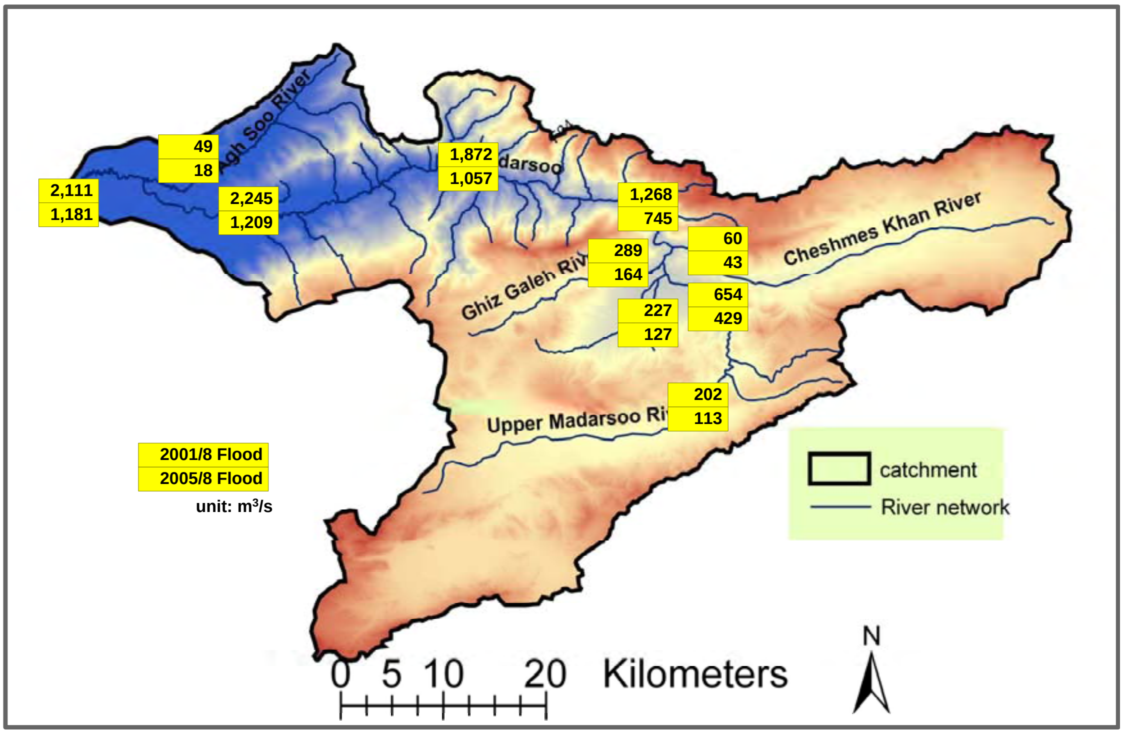


**Fig. PI.13 Flood Peak Discharges in the 2001 and 2005 Floods from Hydrological Simulation**

One of the major traces or scars of the 2001 Flood is a breached earth dam in the Ghiz Galeh River. As presented in the above figure, however, the large flood always came from the upper part of mainstream, the Gelman Darreh River. The simulation results reveal that the major cause of recent disasters was a large amount of floodflow rushing to the Golestan Forest Park from the upper reaches.

As increasing the floodwater through adding floodwater of the tributaries, flood peak discharge of 1,270 $m^3$/s rushed to the gorge of the Golestan Forest where the numerous visitors and campers took rest in August 2001. This fact was verified through interview survey to the village chief of Dasht and farmers cultivating in the lower part of the Gelman Darreh.

After arriving at the entrance of the Golestan Forest, the floodwater further increased its discharge through adding floodwater from mountain streams in the forest and middle reaches, and finally the peak discharge reached to 2,250 $m^3$/s in the Gorgan plain.

### 2.3.3 Sediment and River Morphologic Changes

<u>Debris Avalanche</u>

In the 2001 Flood, debris flow occurred in several mountain streams as shown in the following map. The figure shows that debris avalanche occurred in several mountain streams at the center of Tangrah where the most intensive rainfall core appeared in the 2001 Flood. Debris avalanche carried off lots of camper's lives, and increased energy of the floodwater in the sequential process of avalanche, damming-up of floodwater, collapse of the dam and occurrence of flood surge.

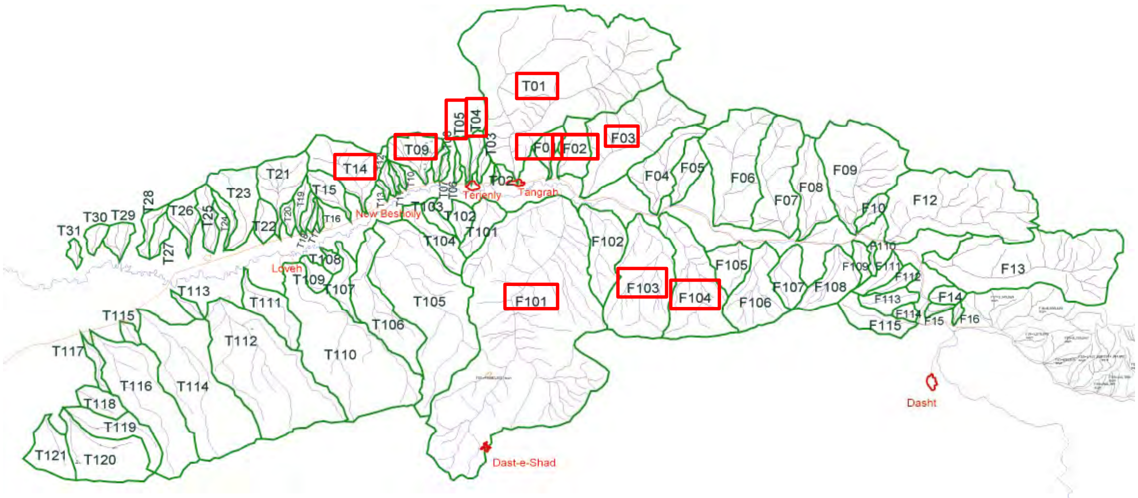


**Fig. PI.14 Mountain Streams of Debris Flow Occurrence in the 2001 Flood in the Middle Reaches of the Madarsoo River Basin**

Note: Red boxes indicate mountain streams in which debris flow occurred in the 2001 Flood.

<u>Sediment Transport</u>

Sediment transport in the mainstream in the 2001 Flood could be briefly described below, based on the field survey and hydrological simulation.

- Sediment transported from the upper part of the Madarsoo River was deposited around Dasht area due to flat topography and decrease of floodwater velocity. These were not only the sediment stored in the basin of the breached earth dam, but also the sediment transported from the Gelman Darreh and Dasht-e-Sheikh rivers. The trace of the deposits could be seen around the polder dike of Dasht village and in the farmland along the Gelman Darreh (See Fig. PI.15).
- After dispersing on the Dasht plain, floodwater converged at the outlet of Dasht plain, and strongly eroded right bank around the confluence with the Cheshmeh Khan River. Simultaneously sudden hydraulic change due to collapse of natural dam might cause valley-head erosion with some 5 m gap at the exit of Dasht village.
- After entering the Golestan Forest, floodwater alternated erosion and deposition in the river channel accompanying with washing out the trees beside the river course. According to DOE, the riparian forest of 500 ha (200 m wide and 25 km long) was washed out so that 35 thousand trees were lost in the 2001 Flood.
- Serious bank erosion occurred along the concave bank at bend and along the protruding edge of tributary's alluvial fan. In this area not only sediment but also trees were significantly washed out.