DATA BOOK
5. GENERAL ENVIRONMENTAL INVENTORY

Department of Irrigation
Ministry of Water Resources
The Kingdom of Nepal

Japan International Cooperation Agency

FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

GENERAL ENVIRONMENTAL INVENTORY FOR THE LAKHANDEI AND BABAI RIVERS

November, 1998

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CHAPTER 1
PROJECT DESCRIPTION

1.1 BACKGROUND

Weak geology, high man-land ratio and unregulated land use practices in the watersheds are some of the causes that accelerated soil erosion and landslides. It has resulted in bank cutting and river meandering in the Terai. These problems have emerged both as a result of human activities and vulnerable mountain ecosystems. Sediment flow along with the flood water result in a rise of the riverbed level and bank erosion, thereby increasing the loss of farm land, settlement and a property, and a destruction of the infrastructure. People experience effects of repeated floods each year during the monsoon season. This problem is prevalent from east to west in the Terai, including the Lakhandei and Babai rivers. These rivers originate in the Chure mountains and have damaged the fertile plain areas in Nepal.

Realizing the menace and loss of repeated flooding and river bank cutting in the Terai, His Majesty's Government - the Department of Irrigation of the Ministry of Water Resources - has prepared a Flood Mitigation Master Plan (FMMP) for eight Terai rivers, with a grant assistance from the Japanese Government through JICA. These rivers, from east to west, are Ratuwa, Lohandra, Lakhandei, Narayani, Tinau, West Rapti, Babai and Khutiya. During this process, JICA included a general environmental study along both banks of the Lakhandei and Babai rivers. This general environmental inventory is one of the components of the FMMP, and the JICA Study Team awarded GOECE Consultant the contract to undertake this study.

The scope of work was to make general environmental inventory in a strip, up to 500 metres wide, on each side of the Lakhandei and Babai rivers in the Terai plains. These rivers have been chosen as priority rivers in the FMMP. Detailed studies are being carried out on the flood mitigation interventions required to: diminish the incidence of river bank erosion; reduce flooding of and damage to land, property and infrastructure; curtail loss of life in humans and domestic animals; and reverse a general deterioration in environment conditions.

Within this broad framework, river bank treatment and protection work has been proposed. These include earth dikes, ring dykes to protect buildings, bank protection with gabions and spurs, river channeling, cut-off channel construction, and bioengineering measures along river banks to reinforce the mechanical bank protection measures.

Some of these interventions will require structures on or near river banks or the planting of trees and grasses in the river plain or on the embankments. Environmental assessments may be required if houses have to be moved because of river protection work. Dykes have been proposed and therefore, the ownership and land use along the possible dyke lines has to be determined. Also, if river banks are planted with trees and grass, the existing use and ownership of these areas has to be known.

1.2 INVENTORY DATA

In order to obtain the relevant information, it was decided to undertake a survey on either bank of the Lakhandei and Babai rivers. Teams of surveyors walked along the river banks in a strip of up to 500 metres wide, to obtain the necessary data. This survey would:

- Record on a 1:10,000 scale topographical map, the land use and land ownership in the strip of land. Different land uses should be indicated with unique colours or shadings etc.
- Record on the map the areas where erosion has taken place and estimate the extent of the erosion damage. This should be shown on the map.
- Count the number of houses and other buildings in this strip and record the building materials used in the house construction. Mark on the map their location.
- Estimate and locate on the map the number of houses or other buildings that are in danger of being destroyed by river currents and/or flooding.
- Enquire about the number of houses and other buildings that have been washed away or moved as a result of this year's (1998) floods; locate these on the map.
- Record the length of roads within the strip, highlight these roads on the map and determine the extent of damage, if any.
- Record the position and lengths of irrigation canals in the strip and indicate damage, if any, to these canals caused by this year's flooding.
- Tabulate all this information on sheets and summarize it in tables.
- Submit this information together with the maps to the JICA FMMP Team.

The field work was undertaken in the month of August when a team of surveyors walked up and down both rivers and recorded the above information on maps and on tables. Data analysis was undertaken in September and October and the draft and final reports were prepared in November 1998.

The detailed information of the inventory is given in the following annexes.

Annex 1. Lakhandei riverside strip: land use and land ownership by area.
Annex 2. Lakhandei riverside strip: number and type of buildings by village.
Annex 3. Babai riverside strip: land use and land ownership by area.
Annex 4. Babai riverside strip: number and type of buildings by village.
Annex 5. Lakhandei riverside strip: topographical maps, showing land use, ownership, land erosion, buildings and infrastructure (2 sets of map scale 1:25,000 and 1 set of map in scale 1:10,000) presented separately.
Annex 6. Babai riverside strip: topographical maps, showing land use, ownership, land erosion, buildings and infrastructure (2 sets of map scale 1:25,000 and 1 set of map in scale 1:10,000) presented separately..

CHAPTER 2
LAKHANDEI INVENTORY

2.1 RESULTS

The length of the Lakhandei river in the Teral is 50,960 metres, or nearly 51 kilometres. In total 35,320,000 square metres were surveyed (3,532 hectares) in a narrow belt on either side of the river. This belt excluded the area of the riverbed. Thus, the average width of the strip on each side of the river is 347 metres. Complete Land use in this belt was recorded and the position of each and every building was noted on the map and riverbank areas that had been eroded were highlighted. Six topographical map sheets of scale 1:10,000 were coloured according to broad land use and land ownership type. The area of each land use was determined and Table 2.1 gives a summary of land use and land ownership.

Table 2.1: Lakhandei River Belt: Land Use and Land Ownership.

Units: hectares

Land Use	Land Ownership				
	Private	Public- state	Public - community	Total	%
Cultivated land	2,955	70	0	3,025	85.9
Barren land	0	154	0	154	4.4
Forest land	0	253	1	254	7.2
Building area	78	1	0	79	2.2
Road/canal area	0	11	0	11	0.3
Total area	**3,033**	**489**	**1**	**3,523**	**100.0**
percentage	86.1	13.9	0.0	100.0	

An estimated 86% of the land in the riverside strip is cultivated (including pasture), 7% is forested, 4% is barren and buildings and infrastructure occupy the remaining 3%. Most of the cultivated land is privately farmed, whereas all the forest land is public. Thus 86% of the land is in private hands and 14% is public land.

The survey estimated that 11,535 metres of riverbank had been eroded this monsoon period: this amounts to 11.3% of the bank length. Practically all the erosion occurred on private land, thus farmers (and house owners) are suffering the most from monsoons.

An estimated 1,820 metres of road were damaged during the monsoons. This damage interrupted the flow of traffic at the height of the floods.

Table 2.2 gives the number of buildings counted in both riverside strips, the number of houses in danger, destroyed or moved because of flooding with an estimate of the population. The length of erosion and road damage length is also given.

Table 2.2: Lakhandei: Population, Buildings and Flood Damage in the Riverside Strips

Lakhandei left and right river strips	
Length of river in the Teral (m)	50,960
Average width of strip (m)	348.5
Number of houses in the area	7,748
Houses destroyed or moved in 1998	75
Houses in danger from flood damage	65
Number of other building in the area	188
Number of people living along the river bank strips	39,960
Population density: people per hectare (ha/person)	11.3 (0.09)
Length of river bank erosion (m)	11,500
Length of road damage (m)	1,820

Nearly 40,000 people live in 8,000 houses along the narrow strip of land next to the Lakhandei river, with on average a building every 13 metres. Thus, this area is densely inhabited and severe flooding would seriously affect many people. In 1998, seventy-five houses were destroyed or had to be salvaged and moved because of flood damage. A further 65 houses are in danger of being destroyed in future flood periods.

Table 2.3 gives the type of buildings found along the river with an estimate of their ground floor areas.

Table 2.3: Lakhandei Riverside: Building by Type and Floor Area

Units: floor area 1,000 m2.

Institutions						Commerce				Houses					
Govern-ment		School		Temple/ Mosque		Shop		Factory		Thatched		Corrugated or wooden		Concrete	
No	A	No	A	No	A	No	A	No	A	No	A	No	A	No	A
16	1.3	15	2.3	63	2.0	25	1.1	69	4.4	4918	190	2587	180	243	15

Note. No = number. A = area.

There are 7,748 houses along the Lakhandei riverside with a ground floor area of 385,000 square metres. Sixty-three percent of these houses are of a simple thatch, with poles and mud, 33% are wooden with a corrugated roof and the remaining 3% are built of concrete or brick. It is estimated that, on average, each building occupies a piece of land twice the ground floor area.

Table 2.4 gives an estimate of the area of land eroded, inundated with coarse material or flooded in 1998. Some of the flooded area is outside the 3,500 ha of riverside land.

Table 2.4: Lakhandei: Estimated Land Area Eroded, Inundated and Flooded in 1998.

	Hectares
Riverside land eroded and lost (average depth 10 m)	12
Land inundated with coarse material	165
Land flooded	1,200

The eroded land was calculated by estimating that on average 10 metres depth of land had been eroded. This is a conservative estimate, for at one site it was observed that ten metres depth of land was eroded in a single 24-hour period. More accurate figures can be obtained from a survey of people who have been affected. Similarly, inundation and flood damage were estimated using information gathered in previous years and making proportionality calculations.

CHAPTER 3

BABAI INVENTORY

3.1 RESULTS

The length of the Babai river in the Terai is 49,840 metres, or nearly 50 kilometres. In total 40,790,000 square metres were surveyed (4,079 hectares) in a narrow belt on either side of the river. This belt excluded the area of the riverbed. Thus, the average width of the strip on each side of the river is 409 metres. Complete Land use in this belt was recorded and the position of each and every building was noted on the map and riverbank areas that had been eroded were highlighted. Seven topographical map sheets of scale 1:10,000 were coloured according to broad land use and land ownership type. The area of each land use was determined and Table 3.1 gives a summary of land use and land ownership.

Table 3.1: Babai River Belt: Land Use and Land Ownership.

Units: hectares

Land Use	Land Ownership				
	Private	Public- state	Public - community	Total	%
Cultivated land	1,525	110	0	1,635	40.1
Barren land	0	455	0	455	11.1
Forest land	6	1,148	806	1,960	48.1
Building area	21	0	0	21	0.5
Road/canal area	0	8	0	8	0.2
Total area	**1,552**	**1,721**	**806**	**4,079**	**100.0**
percentage	38.0	42.2	19.8	100.0	

An estimated 48% of the land in the riverside strip is forested, 40% is cultivated (including pasture), 11% is barren and buildings and infrastructure occupy the remaining 1%. Most of the cultivated land is privately farmed (93%), whereas practically all the forest land is public, except for a small mango orchard and 0.5 ha of private natural forest. Of the forest land, communities manage over 40%: these are mainly plantation areas of *Dalbergia sissoo*. Thus 62% of the land is public and only 38% are in private hands.

The survey estimated that 5,2955 metres of riverbank had been eroded this monsoon period: this amounts to 5.3% of the bank length. Over half the erosion occurred on public land, and some riverside trees were washed away, including mature sal (*Shorea robusta*) a protected tree species. One village of 20 houses was completely destroyed and the families are now living in temporary shelters in a government plantation.

Table 3.2 gives the number of buildings counted in both riverside strips, the number of houses in danger, destroyed or moved because of flooding, with an estimate of the population. The length of erosion and road damage length is also given.

Table 3.2: Babai: Population, Buildings and Flood Damage in the Riverside Strips

Babai left and right river strips	
Length of river in the Teral (m)	49,480
Average width of strip (m)	409.2
Number of houses in the area	1,908
Houses destroyed or moved in 1998	50
Houses in danger from flood damage	66
Number of other building in the area	29
Number of people living along the river bank strips	9,820
Population density: people per hectare (ha/person)	2.4 (0.42)
Length of river bank erosion (m)	5,295
Length of road damage (m)	0

Nearly 10,000 people live in 1,900 houses along the narrow strip of land next to the Babai river, with on average a building every 50 metres. Thus, this area is fairly densely inhabited and severe flooding would seriously affect many people. In 1998, fifty houses were destroyed or had to be salvaged and moved because of flood damage. A further 66 houses are in danger of being destroyed in future flood periods.

Table 3.3 gives the type of buildings found along the river with an estimate of their ground floor areas.

Table 3.3: Babai Riverside: Building by Type and Floor Area

Units: floor area 1,000 m2.

Institutions						Commerce				Houses					
Govern-ment		School		Temple/ Mosque		Shop		Factory		Thatched		Corrugated or wooden		Concrete	
No	A	No	A	No	A	No	A	No	A	No	A	No	A	No	A
0	0	7	0.7	8	0.2	6	0.2	8	0.5	1697	68	186	21	25	1.6

Note. No = number. A = area.

There are 1,908 houses along the Babai riverside with a ground floor area of 90,000 square metres. Eighty-nine percent of these houses are of a simple thatch, with poles and mud, 10% are wooden with a corrugated roof and the remaining 1% is built of concrete or brick. It is estimated that, on average, each building occupies a piece of land twice the ground floor area.

Table 3.4 gives an estimate of the area of land eroded, inundated with coarse material or flooded in 1998. Some of the flooded area is outside the 4,100 ha of riverside land.

Table 3.4: Babai: Estimated Land Area Eroded, Inundated and Flooded in 1998.

	Hectares
Riverside land eroded and lost (average depth 10 m)	5
Land inundated with coarse material	120
Land flooded	520

The eroded land was calculated by estimating that on average 10 metres depth of land had been eroded. This is a conservative estimate, for at some sites, land had been eroded up to a depth of 50 metres. More accurate figures can be obtained from a survey of people who have been affected. Similarly, inundation and flood damage were estimated using information gathered in previous years and making proportionality calculations.

CHAPTER 4

DISCUSSION AND CONCLUSIONS

4.1 COMPARISION BETWEEN THE TWO RIVERS

The two priority rivers chosen for further study by the Flood Mitigation Master Plan Team present a contrast between an area that has been settled for a considerable period - the Lakhandei area, a one that is only now being settled – the Babai area. Table 4.1 shows the population density in the two riverside areas

Table 4.1: Lakhandei and Babai Riversides: 1998 Population and Buildings in the Area.

	Lakhandei	Babai
Length of river in the Terai (m)	50960	49840
Average width of strip surveyed (m)	345	409
Number of houses in the area	7748	1908
Number of other buildings	188	29
Number of people	39590	9820
Population density, (people per hectare)	11.3	2.4

The river bank strip is densely populated along the Lakhandei and at present there is a moderate population density along the Babai. However, serious flooding will affect many households living along the river banks.

The land use and land ownership pattern also presents a contrasting picture. Eighty-six percent of the land is in private ownership in the Lakhandei riverside area, whereas in Babai, 62% of the land is still under government control. Thus, introducing some flood prevention initiatives such as earthen embankments and planting the embankments with trees and grasses will be far easier in Babai than in Lakhandei. Much of the riverside land on the Lakhandei river is farmed. From an environmental viewpoint, riverside strips should be protected with trees and grasses as well as engineering works. However, it may be very difficult to persuade farmers to plant permanent crops on their land along the river embankment, or to allow earthen dykes to be built

Table 4.2 compares the land use pattern of the two riverside strips. Cultivated land, practically all private, accounts for 86% of land use in the Lakhandei, whereas along the Babai river, forest land, at 48%, is the largest form of land use. Over 40% of the forest land are communal in the Babai, but it is less than 1% in the Lakhandei. The area occupied by houses is relatively small on both rivers, but of course, about 50,000 people live along these rivers in the Terai.

Table 4.2: Lakhandei and Babai Riversides: 1998 Land Use Pattern

Units: hectares

	Lakhandei	%	Babai	%
Cultivated land	3025	85.9	1635	40.1
Barren land	154	4.4	455	11.1
Forest land	254	7.2	1960	48.1
Building area	79	2.2	21	0.5
Road/canal area	11	0.3	8	0.2
Total area	3523	100.0	4079	100.0

While fewer houses were destroyed or moved in the Babai riverside strip in 1998, in percentage terms, over twice as many houses were lost in the Babai area. This is shown in Table 4.3

Table 4.3. Lakhandei and Babai Riversides: 1998 Estimated Damage

	Lakhandei	%	Babai	%
Houses destroyed or moved in 1998	75	1.0	50	2.6
Houses in danger from flood damage	65	0.8	66	3.5
Length of river bank erosion (m)	11500	11.3	5295	5.3
Length of road damage (m)	1800	4.6	0	0.0

Erosion damage was much more sever along the Lakhandei river compared to the Babai river. Nearly 50% of the land along the Babai river is still forested, whereas less than 10% of the riverside area on the Lakhandei is covered with trees. This could explain why there is much more erosion along the banks of the Lakhandei. It points to the importance of having permanent vegetation, especially trees, along the banks of streams and rivers.

Table 4.4 compares the area damaged between the two riversides. Again, Lakhandei riverside area suffered the greatest amount of damage. Moreover, the presence of trees in the Babai area could have contributed to the lower loss of land from erosion - less than half -- and the smaller amount of land inundated with coarse material. Also, it is estimated that less than half the amount of land was flooded in Babai as compared to the Lakhandei riverside area.

Table 4.4 Lakhandei and Babai Riversides: 1998 Estimated Area Damaged

Units: hectares

	Lakhandei	Babai
Riverside land eroded and lost (average depth 10 m)	12	5
Land inundated with coarse material	165	120
Land flooded	1200	520

4.2 CONCLUSIONS.

The inventory of riverside land in the Terai on the Lakhandei and Babai rivers provided very useful and contrasting information. The Lakhandei riverside area is densely populated and intensively farmed, whereas the population density is moderate along the Babai and only 40% of the riverside land are farmed on this river. It seems clear, that trees and other permanent vegetation along the Babai river have prevented bank erosion, reduced inundation of farm land with coarse and sterile materials, such as sand, and lessened the amount of flooding to agricultural land.

This points to the importance of trees along the riverside, acting as a soil anchor and a bank protector. From an environmental viewpoint trees should be an integral part of river training work and it is important that, as part of the flood mitigation efforts on all rivers in the Terai, riverside land must be protected with permanent vegetation to reinforce the physical bank protection initiatives.

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6. ENVIRONMENTAL STUDY: LAKHANDEI SUB-WATERSHED

Demartment of Irrigation
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Department of Irrigation
Ministry of Water Resources
The Kingdom of Nepal

Japan International Cooperation Agency

FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

ENVIRONMENTAL STUDY FOR RIVER TRAINING WORKS OF THE BABAI RIVER

FINAL REPORT

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ENVIRONMENTAL STUDY FOR THE RIVER TRAINING WORKS
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8. INVENTORY OF RIVER RELATED DATA

INVENTORY OF RIVER RELATED DATA

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INVENTORY OF RIVER RELATED DATA

1. OBJECTIVE OF INVENTORY

The inventory aims to provide with a list of data necessary for the flood mitigation activities such as survey and investigation, study and analysis, project planning, construction, and maintenance and operation. The list will include information on the location and availability of data, so that the user could find the required river related data.

The inventory also intends to exchange mutually and holds data jointly among the river related offices and activate the use of data.

2. DATA TO BE INVENTORIED

The following nine categories of data will be inventoried:

1) REFERENCE: Research papers, lecture notes, reference books, study reports (not for specific project), technical standards and guidelines, etc. for river, flood mitigation, environmental conservation, etc.
2) LEGISLATION AND POLICY: Laws, regulations and rules, national and regional development plans, sectoral development policies, funding /budgeting, etc. related with river, flood mitigation, environmental conservation, etc.
3) SOCIO-ECONOMIC DATA: Social and economic statistics, economic indexes, etc.
4) TOPOGRAPHY AND GEOLOGY: Topographic maps, aerial photos, survey results, geological maps, boring results, bed materials, land use maps, land system maps, etc.
5) METEOROLOGY AND HYDROLOGY: Meteo-hydrological observatory, recorded data, data processing and analysis, rainfall analysis, runoff analysis, flood flow analysis, sediment yield, sediment flow, water quality, etc.
6) FLOOD AND SEDIMENT DISASTERS: Flood reports, damage records, flood risk (hazard) maps, sediment, flood relief activities, etc.
7) PROJECT AND PLAN: Preliminary study reports, feasibility study reports, detail design reports, design drawings, investigation reports, operation and maintenance rules and records, etc. of specific projects for basin development, water resources development, flood mitigation, irrigation and drainage, river

training, water utilization, urban drainage, etc.

8) CONSTRUCTION METHOD AND COST: Construction method, construction equipment, unit work cost, equipment cost, material cost, labor cost, construction management, etc.
9) CONTRACTOR AND CONSULTANT: Name and capability of contractors and consultants

3. INVENTORY FORMAT

A data-base software "MS-ACCESS97", which is one of the most commonly available database software, will be used for the inventory and searching data. Each data will be input from keyboard in the format specified for the inventory . The input items of each data are proposed as follows:

Data

1) Title of data
2) Person/office that prepares/issues the data
3) Date (year, month) of preparation/issuance
4) Five (5) key words (words which best explain the contents of the data)
5) Form of data: Bound book, leaflet, sheet, paper copy, blue print

Administration

6) Name of office/individual who inputs
7) Name of place where the data are kept
8) Date of data input
9) Contact person on the data: Name of person, phone number.

Others

10) Other remarks or notes on the data
11) Possibility of publicity: Yes or no.

4. DATA NETWORK AND ITS OPERATION

The inventory is prepared, at the present stage, using data collected for the Study on Flood Mitigation Plan for Selected Rivers in the Terai plain. As far as inventories are prepared in a specified format, the inventory has a possibility to be expanded in future as a nationwide inventory database of river-related information. In this regard the following arrangements are recommended:

1) The data network should be established initially among DOI and DIOs, DPTC and DOSC, and the data network should be extended to other river related agencies and organizations that have data and concerns on river-related information.
2) A regulation is necessary to operate the data network orderly. The regulation shall specify a inventory format, procedures for updating data, obligation of each member and services to be provided with, etc.
3) Members of the data network are linked officially by memorandum and practically by exchanging, through internet or by diskette file, inventory files which are input commonly in a specified format.
4) The respective agencies and organizations should perform updating of the inventory file.
5) Publicity and charging for providing with these data depend on the regulation by the agency and/or organization that administrates/keeps the data.

5. INVENTORY DATABASE

A program for the MS-ACCESS 97 (with a file name of "INVENTORY.mdb") was developed for the inventory of river related data. Source file of "INVENTORY.mdb" is also submitted to HMG/N.

Using the "INVENTORY.mdb" with MS-ACCESS 97, data can be inventoried when new river-related data are obtained and searched when the data are required. An "User's Guide for Inventory Database" is attached herewith. The data collected during the Study period have already inventoried in the "INVENTORY.mdb".

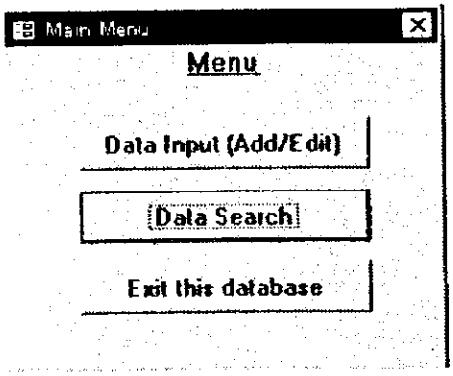
USER'S GUIDE FOR INVENTORY DATABASE

1. Basic Condition

- Computer/Processor: Personal computer with a 486 or higher processor, and display with VGA or higher-resolution video adapter (Super VGA recommended).
- Basic Software: Microsoft ACCESS 97 for Window
- Program files: INVEVTORY.mdb

2. Start-up

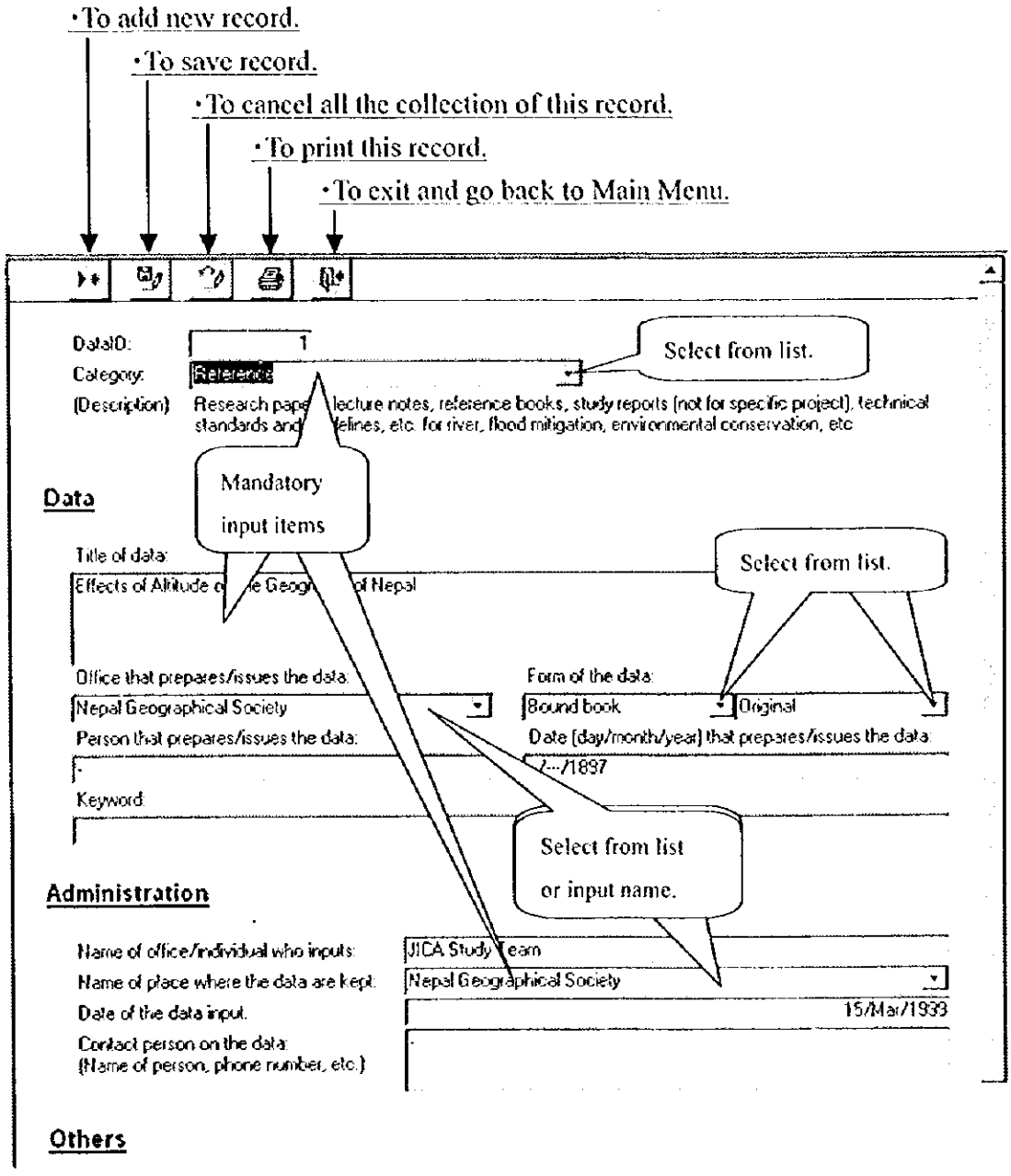
- Install *"Microsoft Access 97"*.
- Run program file *"INVENTORY.mdb"*, and the Main Menu will be displayed automatically.



- For data input or edition, click *"Data Input (Add/Edit)"*.
- For searching data, click *"Data Search"*.
- For closing the program: click *"Exit this database"*.

3. Data Input and Edition

- Click *"Data Input (Add/Edit)"*, and the following form of record will be displayed.
- Fill every field of data. Data for *"category"*, *"Title of data"* and *"Name of place where the data are kept"* are mandatory input items.



4. Searching Data

- Click *"Data Search"* and the following form will be displayed.
- Input word in *"Keyword 1"* and ,if necessary, *"Keyword 2"* for searching.
- Click *"search record button"* to start searching records.