Environmental Impacts of Flood Control Drainage and Irrigation (FCDI) Projects in a Non-Irrigated Area of Bangladesh: A Case Study

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Abstract: *Since 1960s in Bangladesh many water development projects have been implemented mainly for flood control and boosting the agriculture. Among them Flood Control Drainage and Irrigation (FCDI) projects are significant. Various studies reveal the many positive and negative impacts of these projects. Although these projects were implemented so as to support irrigation for High Yield Varieties (HYVs) rice, but due to bad engineering construction some areas do not get irrigation facilities. As a result serious environmental consequences result in those areas. The consequences of the FCDI projects on the environment of those areas never been examined systematically. This study is an attempt to examine the impacts of FCDI projects on some of the agricultural and environmental components of an area without irrigation facilities. A Mouza named Nischintapur within Meghna-Donagoda FCDI project was selected for the study.*

It is assumed that before implementation of this project the characteristics of the environment of the area were almost the same. The FCDI interventions have changed the environment. Therefore, the aims of the study were (1) to identify the impacts of the project on land use, (2) to recognize effects on some of the agricultural components like cropping pattern, intensity, (3) to make a status list of the flora and fauna of the study area; (4) to recognize the cause and effect relationship between the project interventions and IEC (Important Environmental Components) of the study area and (5) to identify the impacts at various environment levels. This study was based on both primary and secondary data. Data were collected from household and Mouza level questionnaire survey, key informants and observation. Mouza map, GIS and statistical methods were used at different stages of the study. The modified EIA method was used for impact assessment of the project in Nischintapur mouza.

The study shows that cropping patterns, cropping intensity and crop diversity have changed in the area. The land use of the area has changed. The physical, biological and agricultural environment has been effected for the lack of water. These have an adverse impact on human life. This study has confirmed and exposed the consequences of FCDI project on environmental components inside the embankment of the area, which does not get irrigation facilities.

Key words: *Bangladesh, Flood Control Drainage and Irrigation Project, Agriculture, Environmental Impacts*

1. Introduction

Bangladesh has many water development projects which often fulfil their purposes but they are also criticized for their environmental impacts. In Bangladesh systematic plans for water development projects started in the early 1960s as a consequence of devastating flooding in 1954 and 1955 (Mirza and Ericksen, 1996). The plans envisaged the construction of a number of physical structures including embankments and drainage systems and where appropriate, the development of an irrigation infrastructure of pumps and gravity flood channels. The principal aim of these projects has been to increase agricultural production by providing protection from high level flooding, and drainage facilities to dispose of excess rainfall during the monsoon season (Alexander et al., 1998). From 1970 onwards, approximately 2 million ha of floodplain have been protected from annual inundation (Siddiqui, 1990). About 18,500 km2 of the estimated 82,000 km2 of the area vulnerable to flooding has been subject to various types of flood protection projects since their inception (Alexander et al., 1998).

Bangladesh has implemented two Flood Control Drainage and Irrigation (FCDI) projects. One is the Ganga-Kapotakkha FCDI project and other is Meghna-Dhonagoda FCDI project. These FCDI projects provide an important defence against extreme flooding and a semi-controlled hydrological environment for growing crops, particularly rice. In Bangladesh, water resources including their natural spread and hydrology are being continuously modified and controlled through water development projects (Ali, 1997). However, most of the projects have been considered only on the basis of economic efficiency, which has in turn been narrowly defined as protecting or increasing rice production. The projects have simply ignored the positive impacts of floods and impacts on the environment (Chadwick et al., 1999). Initially, like other water development projects, the FCDI projects helped improve agricultural production, but recently, negative effects, particularly from the environmental point of view, have become manifest. Negative effects are reported in water, human, land and biological resources of the environment. Various studies (Andriesse, 1982; CIRDAP, 1987; Brammer, 1990; Siddiqui, 1990;

Table 1: *Positive and negative impacts of FCDI projects in Bangladesh*

Impacts	Economical	Social	Physical/Environmental
Positive impacts	Increased rice yields, Increased fish culture in ponds	Increased primary activities in filed, Increased social interaction	Reduce of flood hazards and flood free land, All-year accessibility to land, Expansion of cropping areas
Negative impacts	Loss of common natural resources, Reducing cropping options, Increased dependence on chemical fertilizer and pesticide, Increase cost of agricultural inputs, Decrease in production of supplementary crops, Loss of livestock, Loss of grazing areas	Increase the incidence of diseases such as diarrhea, itchy and malaria etc., Change of occupation, Change of culture and heritage, Loss of water base cultural festivals, Change in social system	Drainage problems, Water logging, Loss of moisture in soil, Deterioration of soil physical properties, Reduction of nutrients derived from flood-borne sediments, Loss of natural food-induced pest control, Increase of monoculture, Reducing agricultural diversity, Loss of fishery habitats, Changes in hydrological regimes, Change in ecosystem, and Increased agrochemical run off and contamination of surface waters

Source: Literature survey

GOB, 1991; Shamsuddin et al., 1992; Rashid, 1992; BWDB, 1994; FAP, 1994; Rahman, 1995; Mirza and Ericksen, 1996; Alexander et al., 1998) identify positive and negative impacts of the projects (Table 1). All the studies report the overall environmental impacts of the projects, though views conflict.

Within the FCDI projects there are some areas which do not get the irrigation facilities due to bad engineering construction. Few studies ever discussed the environmental consequences in those particular areas. Although the history of water development programmes in Bangladesh goes back half a century. Nevertheless the consequences of projects on the environment of the area, which does not get irrigation facilities, have not been examined systematically. The planning, designing and implementation of FCDI projects have never considered or examined the impacts of the projects on the environment in a non-irrigated area. This study is an attempt to examine the impacts of FCDI projects on some of the environmental components of an area which lacks irrigation facilities. The objectives of the study were (i) to establish the impacts of the project on land use; (ii) to draw a picture of the project impacts on cropping patter, cropping intensity and seasonal environmental risk that affect agriculture; (iii) to make a list of the status of flora and fauna (iv) to identify the cause and effect relationship between project interventions and important environmental components; and (vi) to recognize impacts at various environmental levels.

For the study a non-irrigated area within the Meghna-Dhonagoda FCDI project (Figure 1) was selected. This project was started in 1987(FAP-12, 1991). The project aimed at flood protection or reduction thorough the construction of embankments and an improvement of drainage through excavation of canals or through pump drainage and providing irrigation facilities (BWDB, 2008).

2. Methodology

In order to fulfil the objectives of the study different methods were applied. First of all an extensive literature review was carried out to find out the known impacts of FCDI projects and similar projects elsewhere. The objectives of the study and selection of the study area were clarified at this stage. A reconnaissance survey was carried out in the study area based on the knowledge obtained from the literature review in order to identify the problems concerning which data collection would be made.

A preliminary study was carried out in the study area to establish a frame for the main study. The results from the preliminary study indicated that the study area did not get water for irrigation from the project. Primary data were collected through an imperial field observation, questionnaire survey and interviewing with field level key informants. Observations were made to determine land use and land type, cropping patterns, and important environmental components etc. A draft questionnaire was prepared on the basis of the objectives and scope of the research and pretested. The questionnaire was used to conduct the survey using interviews. A total of 250 households were surveyed. Short interviews were conducted with the key informants to collect land use information concerning different season, cropping pattern, intensity, irrigation facilities, flora and fauna and problems and facilities etc. of the Meghna-Dhonagoda FCDI project. The land use survey of the study area was conducted through inventory method. This plot to plot field survey using Nischintapur mouza maps was undertaken when asking questions on land use to the landowners and knowledgeable farmers.

The secondary information was collected through a literature survey. Maps were collected from journals, documents and Department of Land Records and Survey (DLRS). All collected data and information from the primary and secondary sources were tabulated through cross tables and normal tables. Information was also interpreted in the form of hypothetical deductive method. Collected data were analysed to obtain an inventory of the pre and existing conditions of the study area in terms of environmental impacts. ArcView GIS was used to combine the sheet maps to create a Mouza (the smallest revenue unit in Bangladesh) map as well as maps of study area, land use, agriculture and cropping intensity. SPSS software was used to calculate mean, frequency distribution and descriptive statistics during data analysis.

A modified Environmental Impact Assessment (EIA) was used to identify environmental impacts. EIA can be described as a process for identifying the likely consequences for the biological environment and for man's health and welfare of implementing

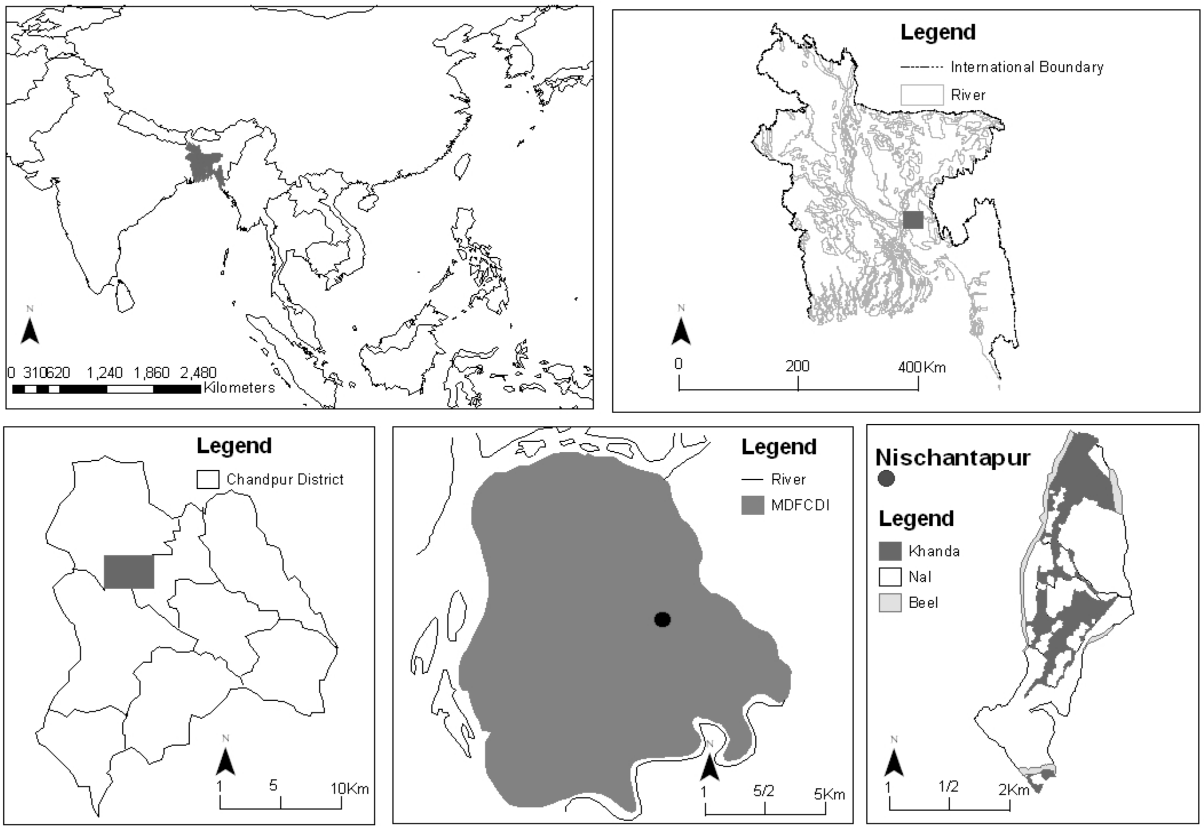


***Figure 1:** Location of the study area in respect of Bangladesh, District and Meghna-Dhonagoda FCDI project area*

particular activities. It is also used for conveying this information at a stage when it can materially affect the decision, to those responsible for sanctioning the proposals (Munn, 1979). Davies and Muller (1983) argue for an extension of EIA definition to cover socioeconomic effects to provide for a unified appraisal. As the EIA was undertaken for a proposed project only, the methods followed for an EIA study were not considered suitable for this study, as the project was two decades old already. The method followed was therefore, modified from that approved for EIA of Bangladesh water sector project (FPCO, 1992). For assessing impacts pre projects conditions, an autonomous development, post project conditions scenarios were developed. All the scenarios were developed on the basis of a literature survey, questionnaire survey, interviewing the key informants and field observations. Therefore, impact assessment of the projects in the non-irrigated area was based on:

A. **Pre project conditions:** These consider the environmental conditions which were to be found in the study area before the project was operational in 1987.
B. **Autonomous development:** These scenarios were developed based in a pre-project scenario reconstructed through memory recall of the key informants. This is the future without project scenarios, even without the project the trend of changes that were active in pre-project condition would have continued. New trends would have developed as a result of country wide changes in the environment. Population pressure would have continued to deplete the environment too. High Yield Variety (HYV) rice would have continued to replace local varieties wherever possible. Some indications of the result of autonomous development were also obtained from areas on the left bank of the Dhonagoda river area that had have remained outside the embankment.
C. **Post project conditions:** These consider the present conditions of the environment of the study area.

D. **Impacts of the project:** These consider the changes likely to occur over the next 20 years with the project in the study area and attempts to separate the impacts of the project from underlying autonomous trends.

3. The study area

Nischintapur Mouza was selected as the study area (Figure 2). The area of the Mouza is about 259.56 ha. It is a part of a flat alluvial delta with elevation 1.5 meters above sea level. There are three land types: (i) Kanda, (ii) Nal, and (ii) Beel. Kanda is a local terms that refers to Medium High Land (F1). It is normally inundated at less than 30 cm deep (FAO, 1988). In pre and post project situation it was not flooded by seasonal inundation. Nal is also a local term which refers Medium Low Land (F_2). It is normally inundated in the range of 90 to 80 cm (FAO, 1988). Before the Meghna-Dhonagoda FCDI project it used to be inundated for 3 to 4 months. Beel is also a local term which refers to Low Land (F_3). It is normally be inundated in the range of 180 to 300 cm (FAO, 1988). Like Nal land Bell land also used to be inundated 5 to 6 months before the implementation of the project. The soil materials of the Mouza are derived from the Brahmaputra, Meghna and other rivers draining from the Assam hills. Almost all the soils are young. Features like channels and basin are distinct here and there is no river. The Beltali canal is the main local drainage channel and Gumti/Dhonagoda River is its parent channel. At present it does not receive water from its parent channel due to the project. It is now very narrow as the embankment has closed its mouth and it is watered only during the rainy season.

Before the Meghna-Dhonagoda FCDI project, 50% of the land used to remain under 1.2 meters to 2 meters of water for a period of four to five months annually, while for the same period 15% of the land used to be inundated by 2 meters to 3 meters of water. For a period of 2 months a year 25% of land used to remain under water of 1 meter to little more than 1 meter. From June to October, the whole area used to be inundated by flood water. At present there is no flood water due to the project and only rain water creates some water logging. There are three types of crop season: (i) Kharif - I (Early summer (March through June)); (ii) Kharif –II (Late summer and fall (July through October)); and (iii) Rabi (Winter cropping season (November through February)). Irrigation facilities of the project are not available in the study area, but flood protection has changed the cropping pattern. HYVs are common practise in most of the agricultural lands.

4. Impacts assessment

The project has affected the environmental components of the study area. The protection from the normal flooding and non-availability of the irrigation facilities has caused environmental impacts in the study area. Based on the objectives of the study, the identified impacts of the project on different parameters of agriculture and environment are discussed below.

4.1 Impact assessment on land use

4.1.1 Pre project condition

General land use was ultimately related to land types in relation to flood depth in pre project condition. In particular, the choice of crops growing and location of homesteads were dependent on flood's depth, duration and timing. The general land use was divided into three categories: settlement, crop area and canals (Figure 2). Among 259.56 ha of land 3.65%, 95.55%, and 1.80% land was settlement, crop area and canals respectively (Table 2). The crop area was divided into Kanda, Nal and Beel land. In pre project conditions Kanda, Nal and Beel land were inundated by 30 cm to 90 cm, 90 cm to 120 cm and 120 cm to 180 cm of flood water respectively (Figure 3). All the canals and wetlands areas belonged to Beel land. Out of 250.09 ha of crop area, 94.53 ha was double crops land (Table 3). Aus (local variety of rice) and Rabi crops were the main crops of this double crops land. The amount of Nal and Beel was 148.78 ha and 6.78 ha. Both the Nal and Beel land were under single crop (Table 3). Mixed Aus, Aman or Boro rice were cultivated there.

4.1.2 Autonomous development

In autonomous development, land use pattern would be the same of the pre project condition. Without project the existing land would not have changed and prevailing cropping practises would have continued in different land types. Due to population pressure, some Nal land would have used for homesteads.

Table 2: *General land use of pre and post project situation*

Land Use	Pre Project Situation		Post Project Situation		Change of Land (ha)	% Change of Land
	Pre Project Area (ha)	(%)	Post Project Area (ha)	(%)		
Settlement	9.47	3.65	13.65	5.26	+ 4.18	44.14
Crop Area	245.40	94.55	243.78	93.92	- 1.62	0.66
Cannels (Khals)	4.96	1.80	2.13	0.82	- 2.85	54.58
Total	259.56	100	259.56	100	-	-

Source: Field survey

Table 3: *Crop land use according to land type in pre and post project condition*

Land Type	Total Area (ha)	Pre Project Condition					Post Project Condition					% of change
		Crop Area (ha)	% of Land	% of Total Land	Crop Prac.	Main Crop Cult.	Crop Area (ha)	% of Land	% of total Land	Crop Prac.	Main Crop Cult.	
Kanda		94.53	37.79		Double crops	Aus (a) + Rabi(d)	94.53	38.44		Single crop	Aus/Rabi	
Nal	259.56	148.78	59.49	96.35	Single crop	Mixed Aus & Aman(b)	144.6 (dec. 2.81%)	58.80	97.74	Triple crops	Aus+ Aman+ Rabi crops	1.67
Beel		6.78	2.72		Single crop	Boro(c) (LV)	6.78	2.76		Double crops	Aus (HYV) Aman (HYV) Bora (HYV)	
Total		250.09	100				245.91	100				

Source: Field survey. Note: (a)Aus means rice growing through March to June, (b)Aman means rice growing through July to October, (c)Boro means rice growing through November/January to April/May and (d)Rabi means winter crops growing through November to February. Generally Rabi crops include crops like oilseed, pulses, wheat, chili, vegetables etc. LV=Local varieties.

4.1.3 Post project Condition

In the post project situation, after two decades, the project has an influence on determining the land use of the study area. The general land use of post project condition is of three types: settlement, crop, and canals (Figure 4). Settlements have expanded in Nal land as the project made the area flood free. The total area of settlement, crop and canals are 13.65 ha, 243.78 ha, and 2.13 ha respectively. A significant change has taken place in canals area as it reduced by 54.58% and it converted as agricultural land (Table 2). The crop area of the post project condition is also divided into Kanda, Nal and Beel. Post project Kanda became flood free, whereas Nal and Beel land is inundated by 30 cm to 120 cm and 120 cm and above respectively (Figure 5). Out of 245.91 ha of crop area 94.53 ha is Kanda and single crop land (Table 3). Aus or Rabi crops are the main crops in this single crop land. The amount of Nal and Beel is 144.60 ha and 6.78 ha respectively. Now Nal land has become triple crop land whereas Beel land has become double crop land. Aus, Aman and Boro rice are the main crops in both the land types.

4.1.4 Impact

There has not been an increase in net cultivated area since all the cultivable land of the study area was already cultivated during at least one season before FCDI project. The settlement has expanded in the Nal because now the area is free from flooding and it is only inundated in the rainy season. The Nal and Beel have converted from single crop land to triple and double crops land (Table 3). The Kanda and Beel land remained the same. Only the Nal has decreased 2.81% (Table 3). The amount of Nal land has decreased because new settlements arose in some

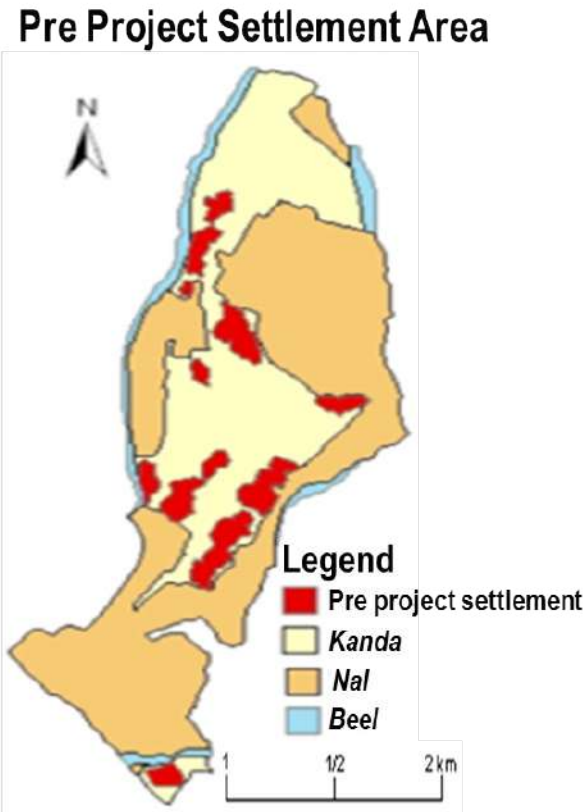


Figure 2: Pre project land use

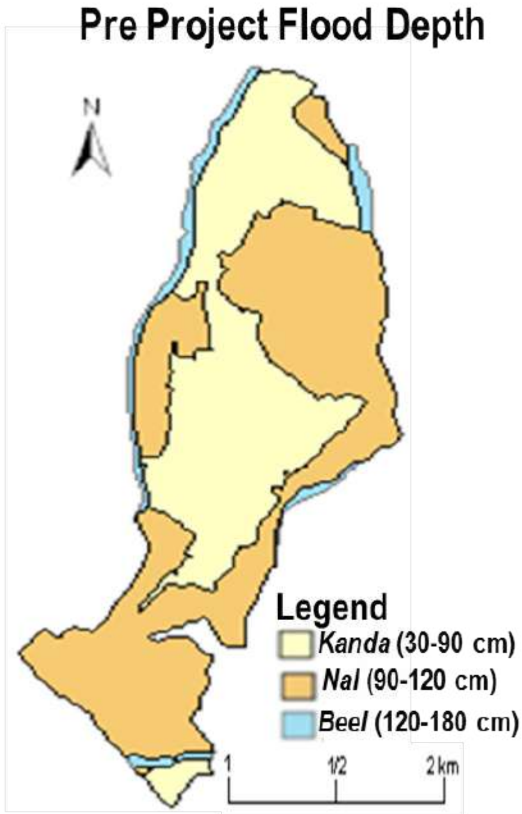


Figure 3: Flood depth in pre project

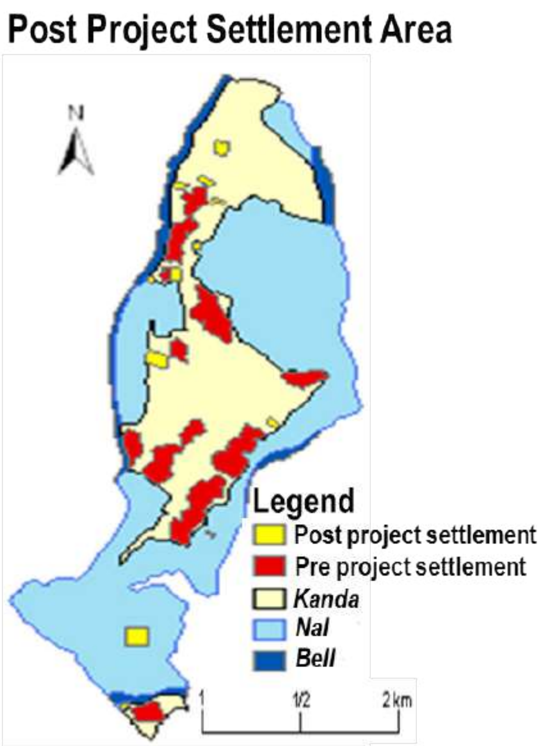


Figure 4: Post project land use

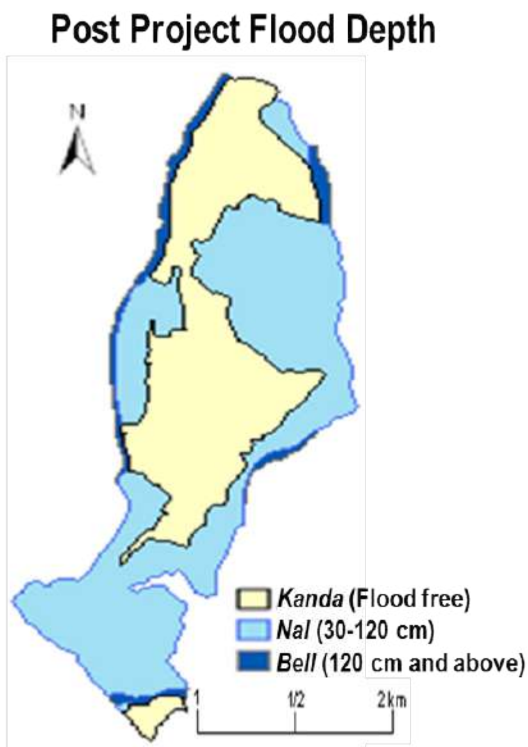


Figure 5: Flood depth in post project

part of that land. Although one of the objectives of the project that increase of HYV rice cultivation has fulfilled but due to lack of irrigation facilities and lack of moisture in soil the Kanda land has become signal crop land where as Nal and Beel land have brought under extensive agriculture. As a result the previous wetlands are disappearing with time. After the project the medium low and low land have become extensive cultivation areas.

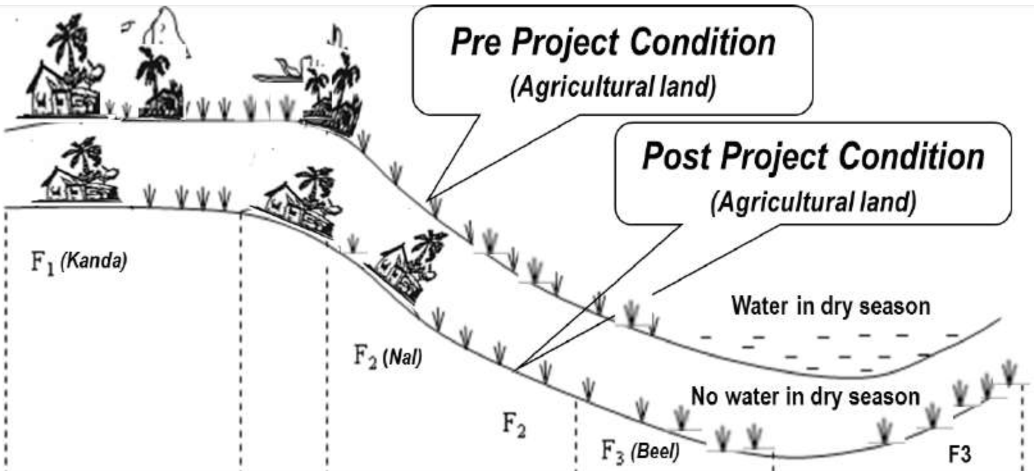
4.2 Impact assessment on cropping pattern

4.2.1 Pre project condition

In pre project condition rice and jute were grown in the monsoon season. B. Aus was grown in early rainy season (Table 4). Jute, Aus and mixed Aus-Aman were practiced in Kharif-I and B. Aman was cultivated in Kharif-II. Aman was the main rainy season crop and Boro and Rabi crops were the dry season crops. Aus crops were harvested in June and July and Aman in July and August. Some jute was grown from March to August. B. Boro rice was sown in November to January and was harvested in April to May in the Beel and in some Nal. Before the project wheat, potato, pulses, chilli, till, china, kaun were the main Rabi crops. These crops were grown from November to May. Based on the survey a general schematic diagram of different cropping season and their agriculture of the pre project situation is shown in Figure 6.

4.2.2 Autonomous development

In autonomous development, at present without project Aus would have grown from March to April and harvested in June to August and T. Aman would have harvested from July to August to November to December and HYV Bora would have cultivated in November to May. In autonomous development, transplanted HYV rice would have been introduced with the programmes of the agricultural extension and population pressure. There would be no broadcasted local rice varieties for the low return of those crops. To compensate for losses due to damage and losses of agriculture land areas, farmers would have



Pre project Season	Kharif -I	Fellow		Jute, Aus, Mixed Aus and Aman	T.Aman	Fellow
	Kharif – II	Fellow		B. Aman	B. Aman (Deep water rice)	Fellow
	Rabi	Boro		Potato, chili, oilseed	Potato, mastered, kolai	Boro
Post project season	Kharif – I	HYV		HYV	HYV	HYV
	Kharif – II	Fellow		HYV	HYV	Fellow
	Rabi	HYV Boro		HYV	HYV	HYV Boro

Figure 6: *Schematic diagram of cropping pattern in different land types in pre and post project situation. Source: Field survey*

Table 4: *Crops calendar in pre project situation of the study area*

Land Types	Crops	Months											
		14Apr-14May	15May-14 June	15June-15July	16July-15Aug	16Aug-15Sep	16Sep-16 Oct	16Oct-14Nov	15Nov-14Dec	15Dec-13Jan	14Jan-12 Feb	13Feb-14 Mar	15Mar-13 Apr
Kanda	Chili												
	Wheat												
	T. Rice												
	Jute												
	Til												
	Pulses												
	Oilseed												
Nal	Wheat												
	B. Aus												
	Aus + Aman												
Beel	B. Rice												
	Boro												

Source: Field survey and reconstruction from the memory recall. Note: B. Rice means broadcasted rice and T. Rice means transplanted rice.

likely to increase HYV Boro cultivation by installing more low-left pumps along with local irrigation system.

The additional irrigation would have probably involved in Kanda (F_1) and Nal (F_2) land types, replacing the B. Aus/Aman/Robi season cropping pattern with T. Aman and HYV Boro. This replacement would have decreased cultivation of pulses and local rice verities. For extensive cultivation of HYVs rice as well as for not getting good return from Jute farmers would cultivated Jute in a very small-agricultural land. Without FCDI project HYV crops would have begun to introduce and only one paddy cultivation would possible in the Nal and Beel land due to flooding. The Rabi crops (i.e. pulses, potato, till, kaun, chilli and vegetables) would have grown in Kanda land from November to May. The Kaun would have disappeared from the cropping pattern as food habit has changed.

4.2.3 Post project Condition

The project has very favourably affected extensive cultivation of paddy at the expense of mainly jute (in Kharif - I), wheat, pulses, oilseed and other Rabi crops (in the Boro/Rabi season). The dominance of paddy in the cropping pattern is clear from the fact that paddy occupies all land types at present. This extension in paddy cultivation has occurred mainly in Boro/Rabi and Kharif-I season (the previous moisture deficit season) mainly due to the project. A detail crop calendar of the post project situation is given in Table 5. The project seems to have strengthened the dominance of HYVs even within the newly evolved paddy cropping pattern in every season, monsoon to Boro. The reduction of flood loses due to the project have significantly promoted the cultivation of T.HYV Aus, B.HYV Aus, HYV Aman, and HYV Boro in the study area. Because of the project framers have started to cultivate these high yield crops instead of lower yield and lowest cost B. Aman and mixed Aus/Aman. Among the Aman crops T.HYV Aman is the most prominent crop in the study area while local B. Aman was the most prominent in pre project condition. HYV rice is cultivated at Rabi, kharif-I, Kharif-II season. Now T. Aman follows T. Aus.

4.2.4 Impacts

The project has led to the introduction of HYVs in all crops lands and a significant shift to T.HYV Aus and marginally to B.HYV Aus from the traditional mixed B. Aus /Aman, local B.Aus, Boro LV and jute; to T.HYV Aman from local B. Aman; and to HYV Boro from LV Boro. In general the increased and/or newly introduced crops involve more crop production costs compared to the displaced ones but the prevailing more stable crops. The project now encourages the farmers of the area to grow these costlier varieties because they bring higher yields and higher returns for some years after the completion of project. Table 6 indicates the impact of the project on cropping patterns. In addition to strengthening the dominance of paddy in the cropping pattern, the project has also been successful in including variety changes within the paddy cropping pattern, particularly from local to HYV varieties and from broadcast to transplant varieties. The project impact has been that Nal and Beel lands have come under HYV monoculture and are cultivated thrice in Nal lands and Twice in Beel lands.

4.3 Impact assessment on cropping intensity

4.3.1 Pre project condition

The study area was very suitable for cultivation but the cropping intensity was very low in the study area. In the pre project situation, the cropping intensity of Kanda, Nal and Beel land were 200%, 100% and 100 % respectively (Table 7 & Figure 7). In Nal and Beel land cropping intensity was low as they were seasonally flooded and there were traditional agricultural practices on those lands. However, the percentage of cropping intensity of the total area was 137.80%.

Table 5: *Crops calendar in post project situation of the study area*

Land Types	Crops	Months											
		14Apr-14May	15May-14 June	15June-15July	16July-15Aug	16Augt-15Sep	16Sep-16 Oct	16Oct-14Nov	15Nov-14Dec	15Dec-13Jan	14Jan-12 Feb	13Feb-14 Mar	15Mar-13 Apr
Kanda	Sugarcane	■	■	■	■	■		■	■	■	■	■	■
	Chili	■	■							■	■	■	■
	Oilseed							■	■	■	■	■	
	Pulses						■	■	■	■	■		
Nal	T.Aus (HYV)	■	■	■	■	■					■	■	■
	T. Aman (HYV)				■	■	■	■	■	■			
	Chili										■	■	■
	Wheat							■	■	■	■	■	
	Oilseed	■									■	■	■
	Pulses							■	■	■	■		
Beel	T. Aus (HYV)	■	■	■	■								■
	Boro(HYV)							■	■	■	■	■	■

Source: Field survey. Note: Aua and T. Aman means transplanted Aus and Aman rice.

Table 6: *Changes in cropping patter and crop varieties according to land types due to the project Table 6: Changes in cropping patter and crop varieties according to land types due to the project*

Land types	Cropping pattern (pre project)	Cropping pattern (Autonomous Development)	Cultivated crops (post project)	Impact
Kanda(F_1)	B.Aus/T.Aus + Jute Kaun and Rabi crops	B.Aus /T.Aus+ Jute Rabi crops	B.Aus (HYV)	Jute (-ve) Rabi crops (-ve) HYV rice (+ve)
Nal(F_2)	B.Aus(LV) B.Aus+B.Aman (LV)	T.Aus(HYV) T. Aman(HYV)	T.Aus(HYV) T.Aman(HYV) Rabi Crops	B.Aus(-ve) B.Aman(-ve) T.Aus&Aman(-ve) Rabi crops(-ve)
Beel(F_3)	Boro(LV)	T.Aman(HYV) Boro(HYV)	T.Aman(HYV) Boro(HYV)	Boro(LV)(-ve) HYV rice(+ve)

Source: Field survey. Note: (-ve) indicates adverse impact of project, (+ve) indicates beneficial impacts of project, LV means local variety, B.Aus and B.Aman mean broadcasted Aus and Aman, T.Aus and T.Aman mean transplanted Aus and Aman.

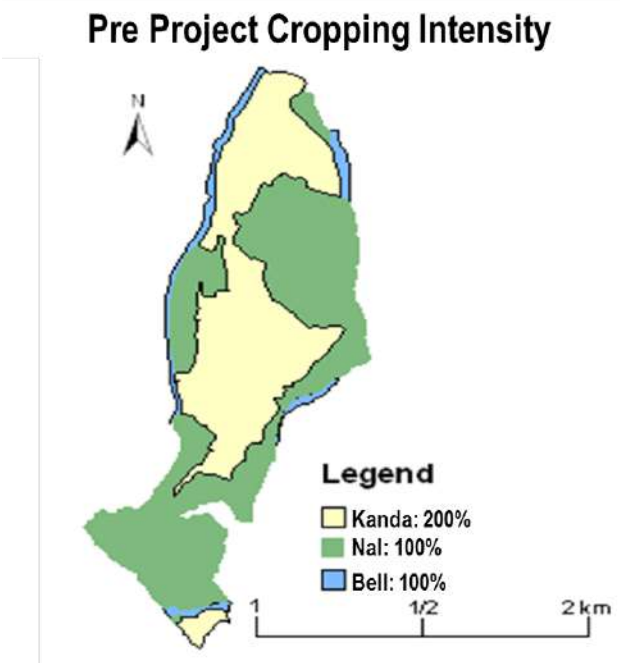


Figure 7: Cropping intensity pre project condition

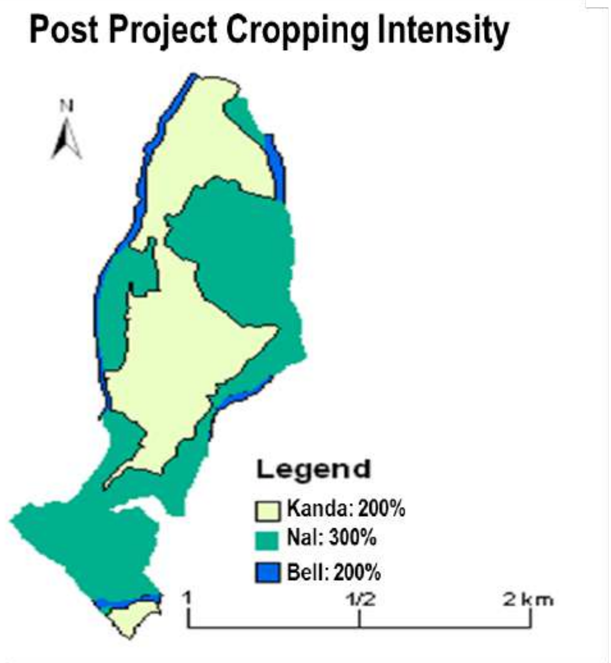


Figure 8: Cropping intensity in post project condition

Table 7: *Cropping intensity in pre and post project condition of the study area Table 7: Cropping intensity in pre and post project condition of the study area*

Land types	Pre project condition				Autonomous Development				Post project condition				Impact on cropping intensity	% of change of cropping intensity
	Net cropped area (ha)	Crop practise	Total cropped area (ha)	% of cropping intensity	Net cropped area (ha)	Crop practise	Total cropped area (ha)	% of cropping intensity	Net cropped area (ha)	Crop practise	Total cropped area (ha)	% of cropping intensity		
Kanda (F_1)	94.53	2	94.53X2 = 189.06	200	94.53	3	94.53X3= 283.59	300	94.53	2	94.53X2= 189.06	200	81.97	46.34
Nal (F_2)	148.78	1	148.78X1 =148.78	100	148.78	1	148.78X1= 148.78	100	144.6	3	144.6X3= 433.80	300		
Beel (F_3)	6.78	1	6.78X1 = 6.78	100	6.78	1	6.78X1 =6.78	100	6.78	2	6.78X2 = 13.56	200		
Total	250.90		344.62	137.8	250.90		439.15	176.88	245.91		636.42	258.80		

Source: field survey

4.3.2 Autonomous development

Following the trend of outside the project it can be assumed that the Kanda land would have come under three seasons crops for the requirement of more food, but the crop cultivation in the Nal and Beel land would be the same as pre-project. It can be assumed that a small amount of Nal land would have changed to become homesteads because of population pressure. According to this assumption the percentage of cropping intensity of the total area would be 176.88 % (Table 7).

4.3.3 Post project Condition

At present the cropping intensity of Kanda, Nal and Beel land are 200%, 300% and 200 % (Table 7 & Figure 8). Cropping intensity has increased in Nal and Beel land as they have come under triple and double cropped land. The percentage of cropping intensity of the total area is now 258.80%.

4.3.4 Impacts

The cropping intensity has increased due to extensions of the cropping period. Cropping intensity is 46.38% higher that the pre project situation (Table

7). In the study area the project impact on cropping intensity is 81.97 %. The intensity has increased mainly in Nal and a Beel land, parts of which remained fallow either in Aus or in Boro season or in both before the project was implemented presumably due to moisture stress.

5. Lost, endangered and vulnerable of flora and fauna species

Due to the project and population pressure serious biodiversity degradation has occurred in the study area. A list of lost, endangered and vulnerable flora and fauna of the study area was made from the field investigation, questionnaire and field survey (Table 8). Among the listed flora and fauna, some species have been lost, some are endangered and some are vulnerable. Habitat destruction, over exploitation, pollution and introduction of exotic species are some of the causes of biodiversity losses.

6. Cause and effect relationship

The cause and effect relationship between the project interventions and water, land, biology and human were identified. The overall cause and effects relationship are shown in Figures 9 to 15. First of all the impacts of project interventions on water of the study area was identified. Then a picture of impacts from water to land, water to human, water to biology, land to human, land to biology and biology to human were portrayed.

Table 8: *Lost, vulnerable and endangered flora and fauna in the study area.*

Local Name -Flora	Scientific name	Diversity	Types	Status	Causes of decline
Kalmisak	Ipomea aquatica	Flora	Shurbs	Endangered	Anthropogenic stress and project
Urigas	-	Do	Do	Lost	Habitat destruction for project
Ghechu	Aponogeton echinatus	DO	Do	Do	DO
Padma	Nelumbo mucifera	Do	Do	Do	Do
Bonna	-	Do	Do	Endangered	Anthropogenic stress and project
Hijal	-	Do	Tree	Lost	Do
Local Name -Fauna	Scientific name	Diversity	Types	Status	Causes of decline
Sona Bang	Rana tigrina	Fauna	Amphibian	Do	Indiscriminate hunting and habitat reduce
Kashim	Lissemys punctata	Do	Reptiles	D	Do
Dora Sap	Amphiesma stolata	Do	Do	Vulnerable	Habitat reduce
Pan Cowri	Phalacrocorax riger	Do	Bird	Lost	Indiscriminate hunting and habitat reduce
Go Bok	Bubulcus ibis	Do	Do	Do	Do
Sada Bok	Ardea alba	Do	Do	Do	Do
Bhuban Chil	Milvus rigrans	Do	Do	Do	Do
Udbiral	Lutra lutra	Do	Mammals	Do	Habitat reduce and crisis of food
Mechibagh	Felis vivirira	Do	Do	Do	Do
Air	Aorichthys aor	Do	Fish	Do	Indiscriminate hunting and habitat reduce
Baim	Baim sp.	Do	Do	Vulnerable	Do
Bheda	Nandas nandas	Do	Do	Endangered	Do
Boal	Wallagu atta	Do	Do	Vulnerable	Do
Chetal	Notoptocus chitalla	Do	Do	Lost	Do
Foli	Notopterus notopterus	Do	Do	Do	Do
Koi	Anabas testudineus	Do	Do	Vulnerable	Do
Shing	Neteropreustes	Do	Do	Do	Do
Shoal	Channa striatus	Do	Do	Do	Do
Taki	Channa puctus	Do	Do	Do	Do
Magur	Clarias buttachus	Do	Do	Do	Do

Source: Field survey

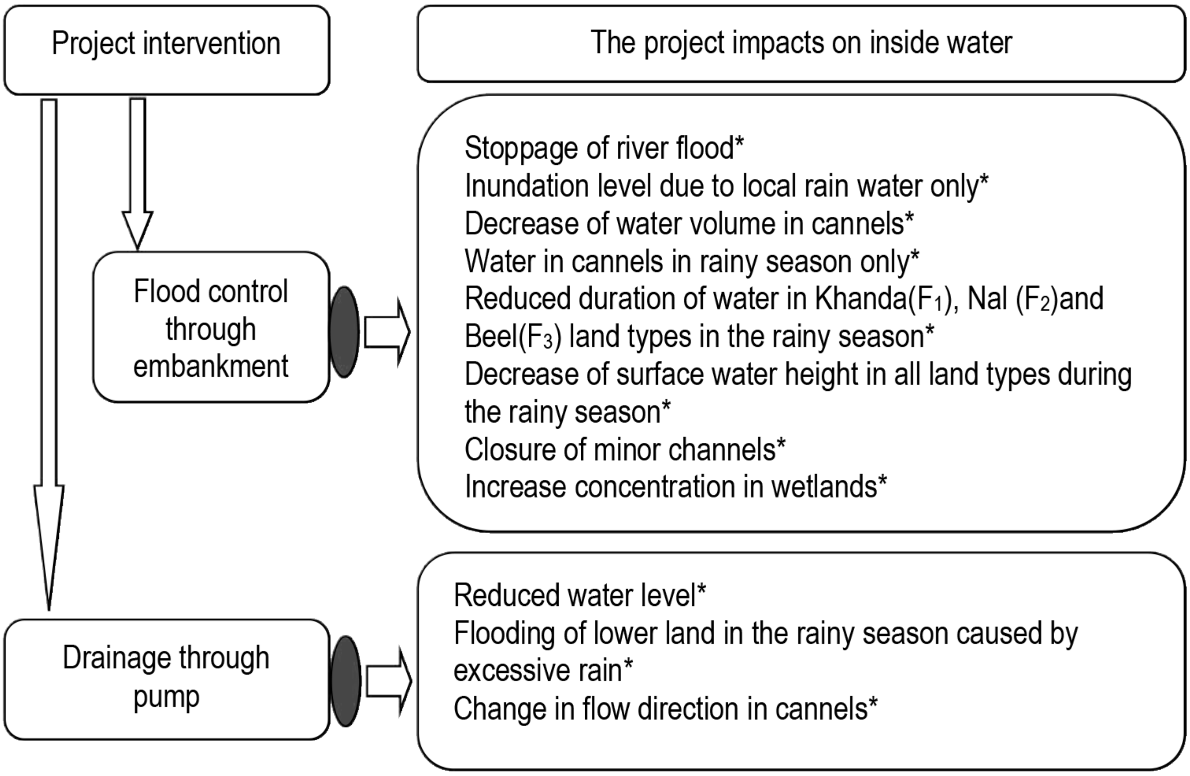


Figure 9: *Linkage of impacts due to project interventions*

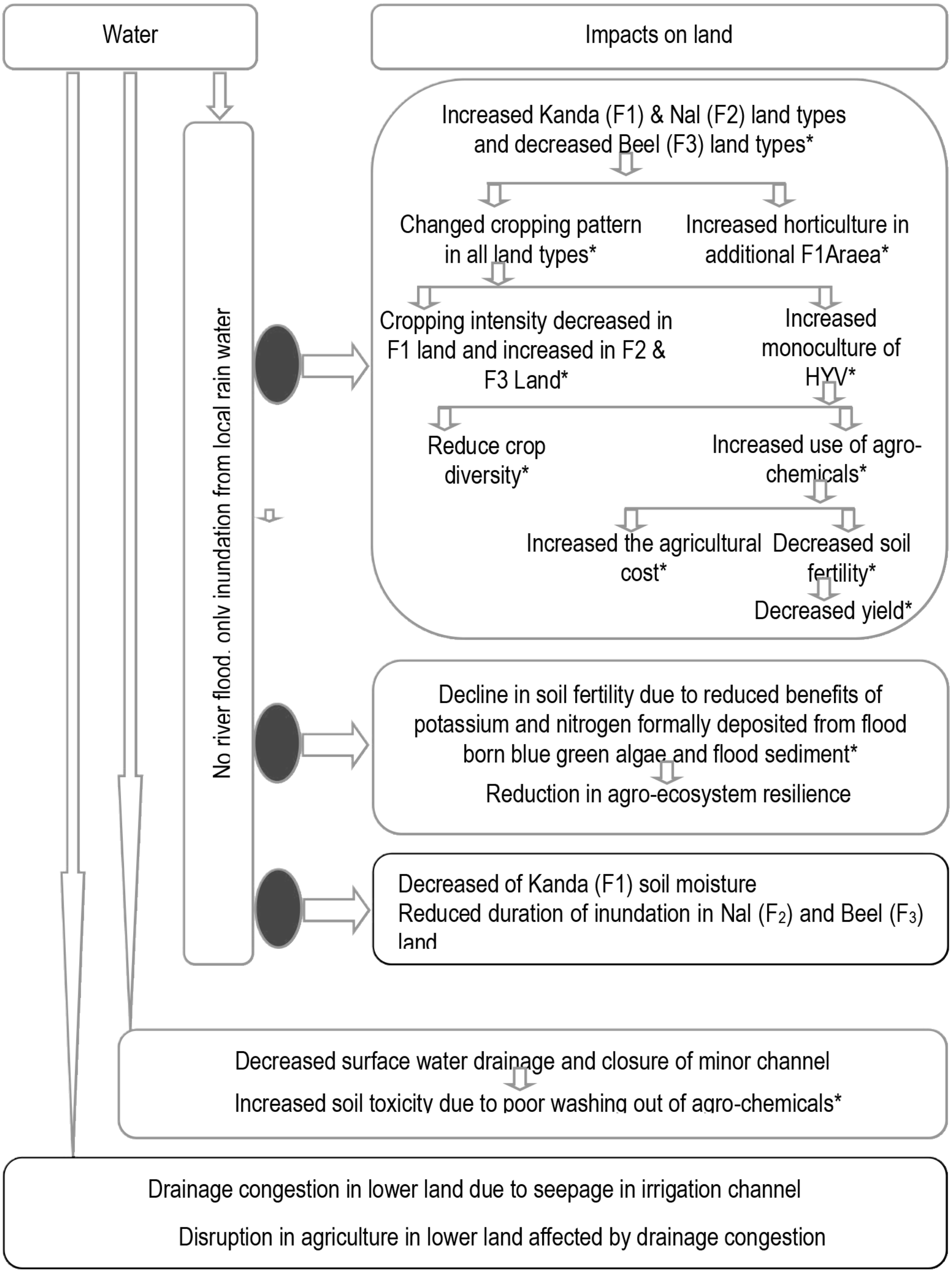


Figure 10: *Impacts from water to land*

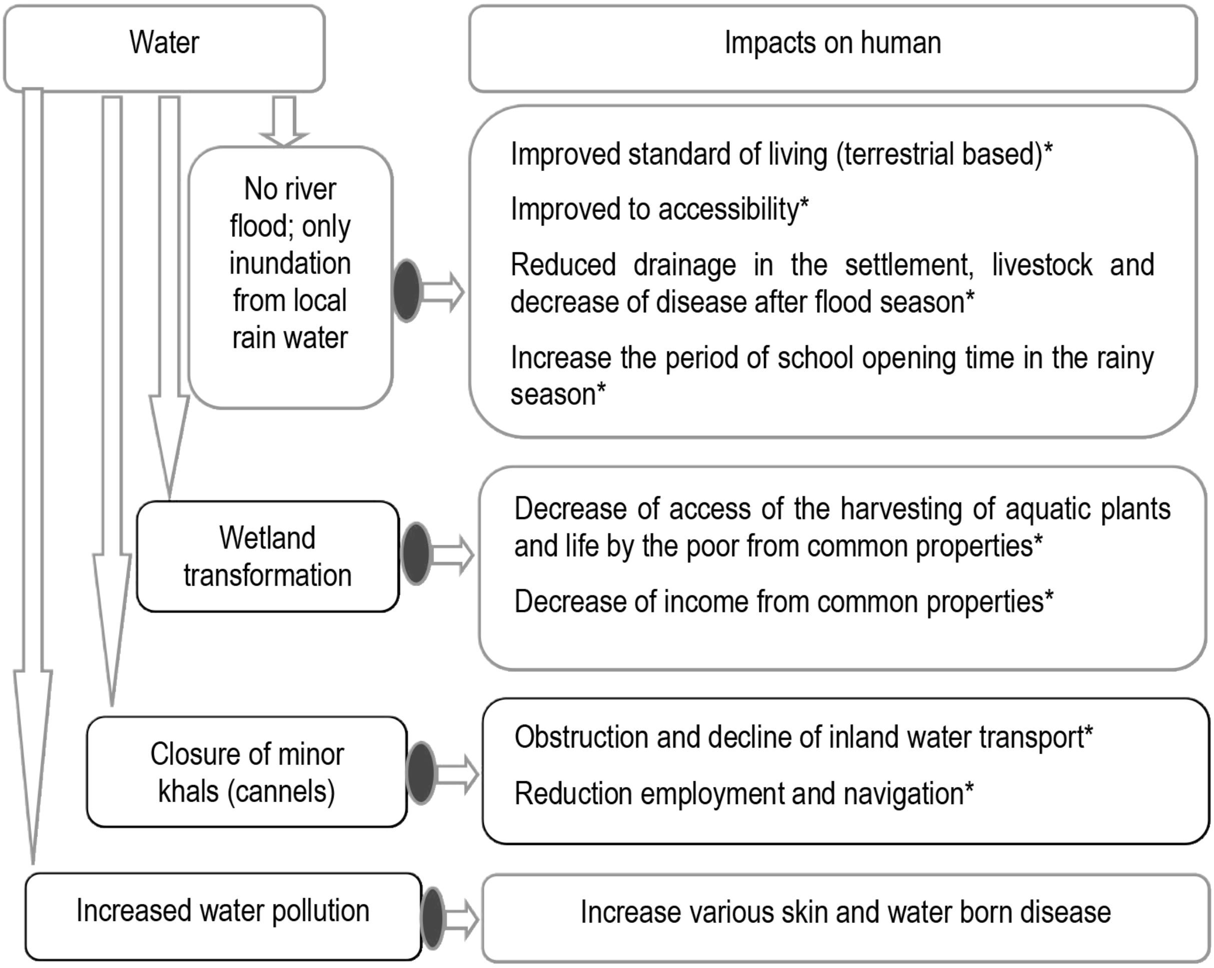


Figure 11: *Impacts from water to human*

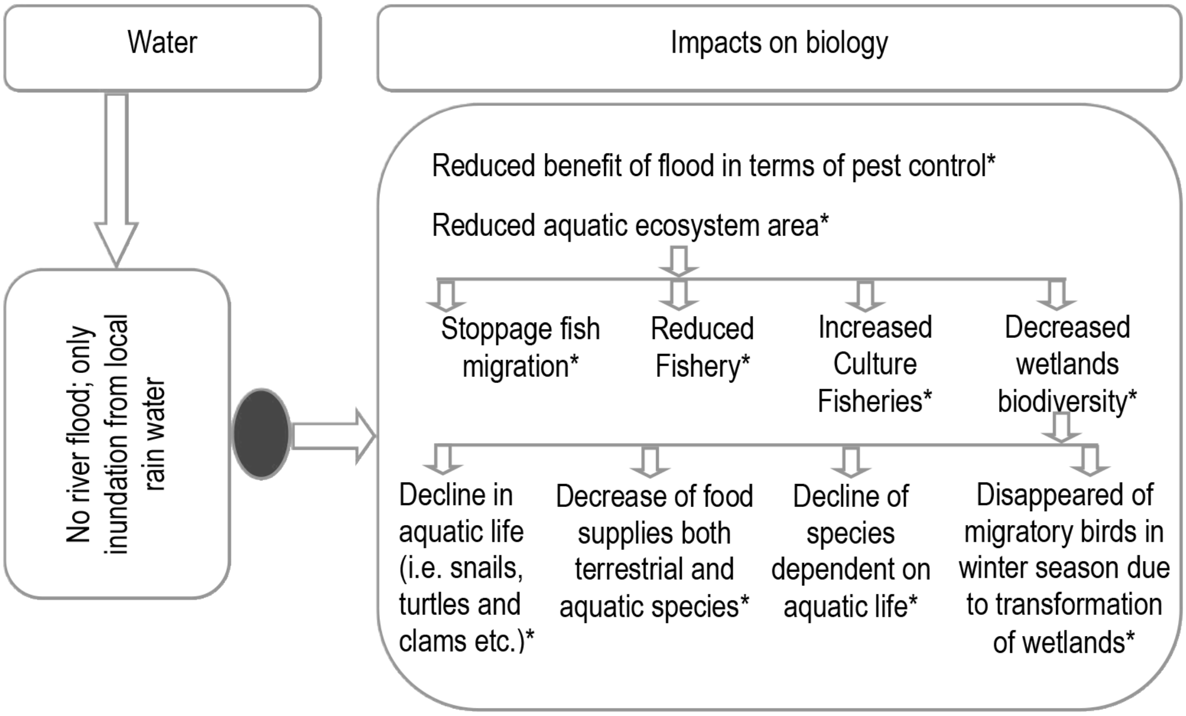


Figure 12: *Impacts from water to biology*

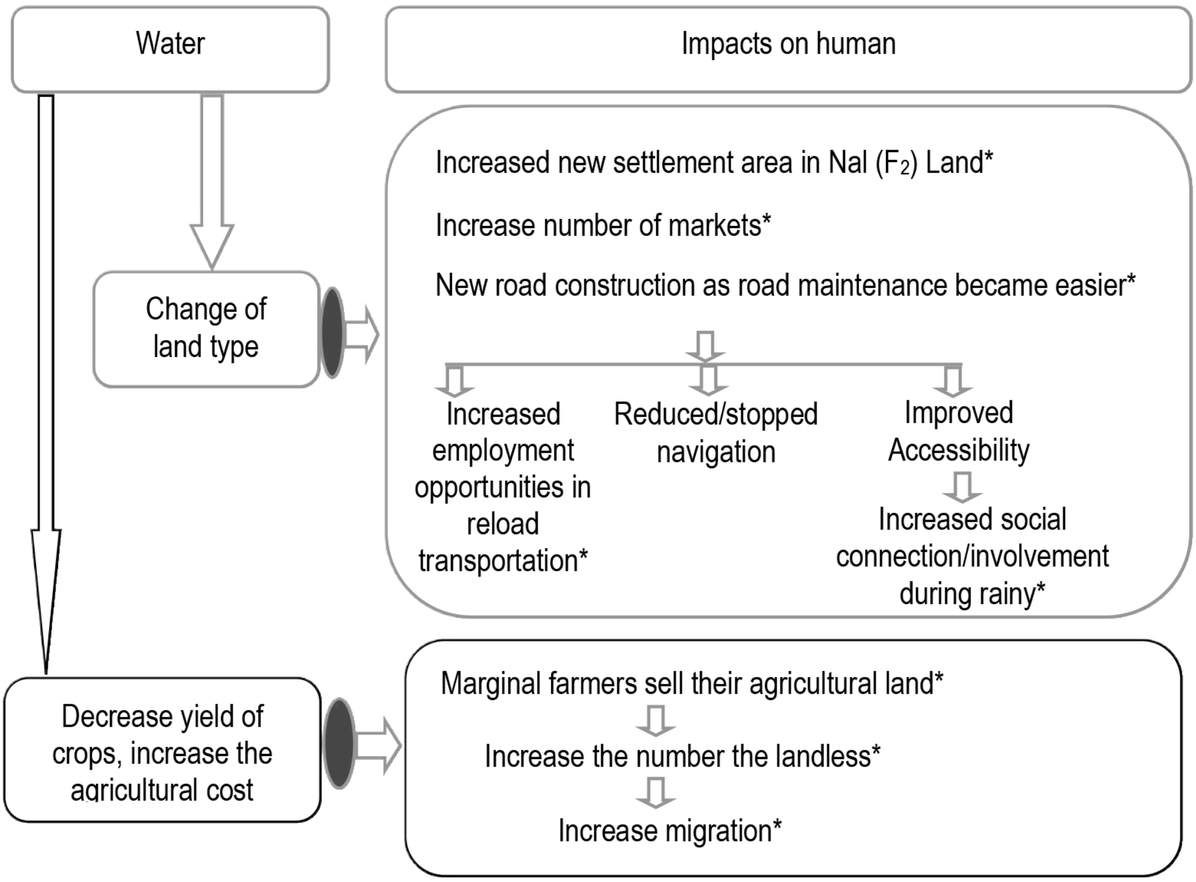


Figure 13: *Impacts from land to human*

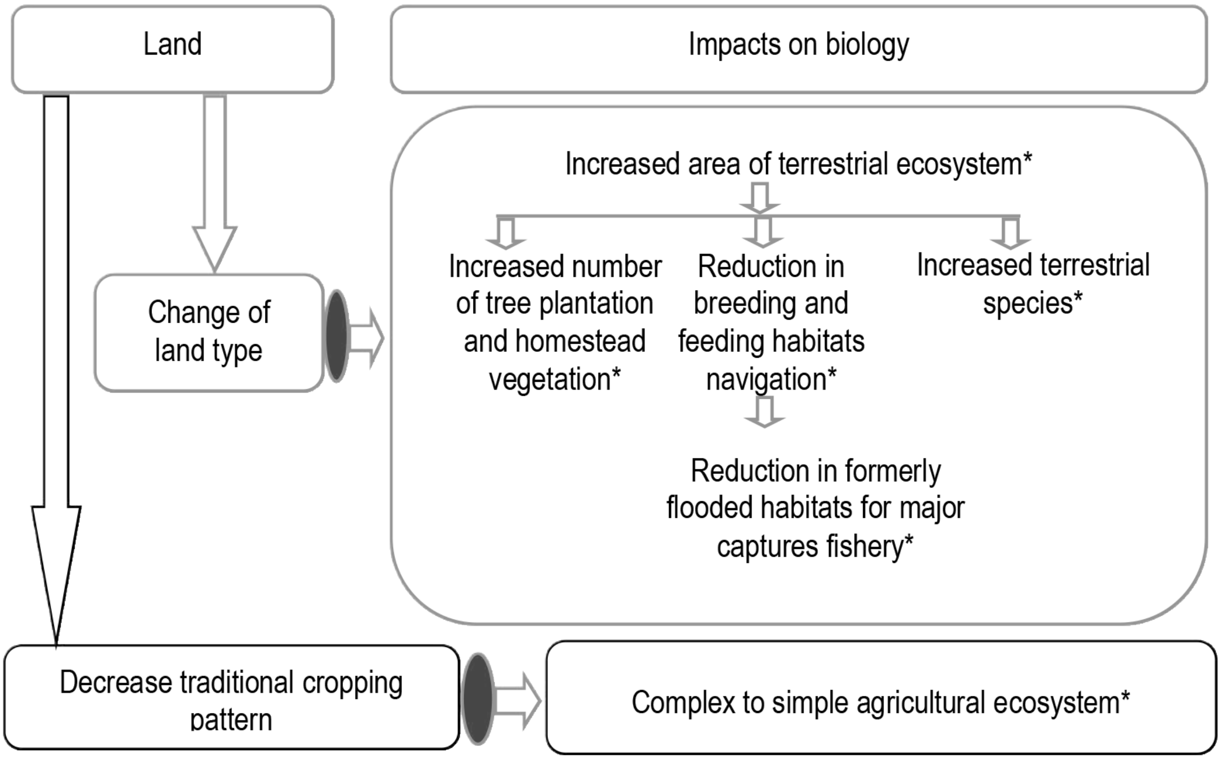


Figure 14: *Impacts from land to biology*

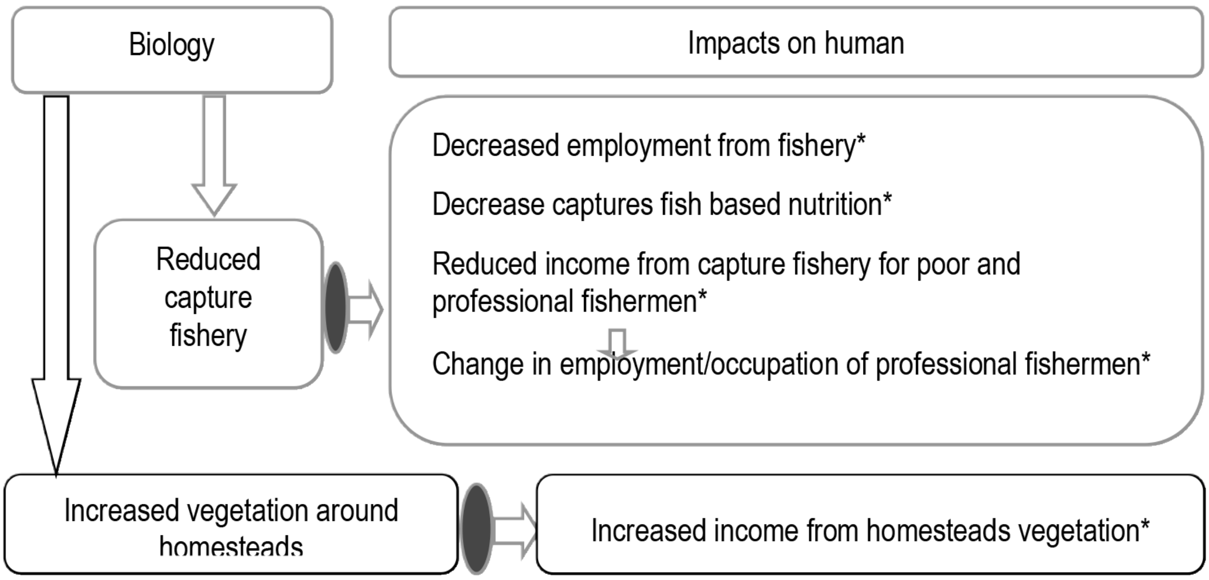


Figure 15: *Impacts from biology to human*

7. Impacts at various environment levels

The overall project impacts on various Important Environmental Components (IEC) of the study area were identified. This identification gives scenarios of the impacts of the project in the study area (Table 9).

Table 9: *Environmental impact of the MDFCDI project on the study area. Source: Field survey*

Important Environmental component(IEC)	Pre project situation/conditions	Project impact
River flood	Flood of medium height every 5 years Major flood every 10 to 15 years	Stoppage of all floods
Water level in cannels	Rainy season: High water level Dry season: Moderate water level	Low water level in rainy season but dry in dry season
Duration of water in cannels	12 months	7 to 8 months(April to November)
Duration of water in Khanda (F_1)	Seasonal	No water
Duration of water in Nal(F_2)	3-4 months	2 months
Duration of water in Beel(F_3)	7 months	4 months
Duration of water in wetlands	Permanent	7-8months
Draiange through minor cannels	Well draiange	Very poor/totally stopped
General drainage in rainy season	Well drainage	Poor drainage
Water quality in wetland	Little pollution from agrochemicals due to flushing	More pollution from agrochemicals due to reduced flushing
Land area of various agricultural land types	Khanda (F_1):94.53ha, Nal (F_2):148.78ha. Beel (F_3):6.78ha.	Khanda (F_1):94.53ha, Nal (F_2):144.6ha. Beel (F_3):6.78ha.
Wetland	Permanent wetland	Transform into crop land
Cropping pattern	F_1:3crops, F_2:2crops,F_3:1crops Traditional crops + HYV	F_1:1crops, F_2:2crops,F_3:2crops only HYV in F_1 and F_2
Cropping intensity	F_1:300, F_2:200,F_3:100	F_1:100, F_2:300,F_3:200
Crop diversity	Number of rice and other crop varieties	Reduce of number of rice and other crop varieties
Crop damage due t flood	High	Low
Crop damage due to pest attack	Low	High
Soil quality	Annual deposition of sediment carrying nutrient and BGA	Reduction/stoppage of nutrient carrying sediment and BGA
Soil moisture	High in all land types	Low in F_1land type
Homestead vegetation	Low both in cover and diversity	High both in cover and diversity
Endanger species	None	4 species
Vulnerable species	None	11 species
Lost species	None	10 species

Important Environmental component(IEC)	Pre project situation/conditions	Project impact
Pest species	Large	Large
Pesticide concentration in wetland	Low	Moderate to high
Natural pest control	Moderate control by flood /inundation	Low control by flood/inundation
Fish migration	Free extensive fish migration	Totally stopped
Capture fish diversity	26 species	Lost:3,Vulnarable:7, Endangered: 1
Culture fishery security from flood	Low	High
Wetland biodiversity	Flora: 14, Fauna; 41	Flora: 10, Fauna: 35
Winter migratory bird	High	Stopped
Terrestrial ecosystem	Large	Small
Terrestrial species	Large	Small
Agricultural ecosystem	Complex	Simple
Settlement area	9.4 ha	13.6 ha
Markets	Total number:1	Total number:2
Road construction and maintenance cost	Moderate	Low
Road transport based local employment	Medium to low	High to medium
Navigation based local employment	High	No
Migration	Low	High
Landless people	Low	High
Selling agricultural land	Low	High
Accessibility(within/outside)	Low	High
Flood damage	High	Stopped
Harvesting of aquatic resources	High	Low
Income from common resource	High	No
Inland water transport	Extensive	No
Skin and water born disease	Moderate	Hugh
Fish based nutrition for poor	High	Low
Income from capture fishery	High	Low
Income from homestead vegetation	Medium	High
Risks to life and property	High	low

8. Conclusion and recommendations

Land, water and biological resources are key components of the natural resources of any country. These resources are fundamental for sustainable economic development. This is particularly true for the developing countries which have large subsistence sectors that depend on land and water resources. However, these resources are increasingly being subjected to intense pressure brought by human activities. The FCDI project is one of the man-made projects which have caused great concern as it has impacts on the natural resource base of the country. The beneficial and non-beneficial effects are shown by research into these projects. This study also confirms the environmental impacts of a project. The major conclusion of the study may be divided into the following categories: (i) within the short period of the project, some significant negative impacts and changes in environmental components have taken place already, (ii) the land use has changed, (iii) The cropping pattern has change and is now HYV rice based (iv) cropping intensity has increased.

This study within the very limited objectives has confirmed the views exposed in other studies regarding the consequences of FCDI projects on environmental components. It has also raised a number of questions and only the future in depth studies with broader scope can answer of those questions. Some of the questions are more academic and theoretical in nature. Other questions are directly related to the sustainability of a more productive agro-ecological environment, which is the aim of the FCDI project to create. These questions are farmed in the form of recommendations.

1. Direct and indirect cause and effect relationship for the difference should be identified in future studies as well as cumulative and non-cumulative impact.
2. Long term monitoring in the same area should be carried out for detecting foreseeable as well as unforeseen changes in environmental components so that timely mitigation action may be taken for necessary environmental management.
3. Detail baseline environmental studies should be undertaken before the implementation of FCDI project, so that changes after implementation may be monitor without conference of memory recall.
4. The people and the farmers should be trained in good environmental management.
5. In view of the past problems and continued high link to physical and human environment issues there appears to be a need for full environmental project audit at a time the satisfactory restoration of the embankment.

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