SINDH IRRIGATION AND DRAINAGE AUTHORITY

Sindh Water Sector Improvement Project Phase-I (WSIP-I)

PREPARATION OF REGIONAL MASTER PLAN
FOR THE LEFT BANK OF INDUS, DELTA AND COASTAL ZONE

Final Report

Volume-I

Main Report

The Louis Berger Group Inc.

In

Indus Associated Consultants (Pvt.) Ltd.

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MAIN REPORT

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VOLUME – I

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In Association with
Indus Associated Consultants (Pvt.) Ltd.

August 2013

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Letter of Transmittal

5, August, 2013

Dear Mr. Junejo,

We are pleased to submit the final report of the Study "Regional Master Plan for the Left Bank of Indus, Delta, and Coastal Area" (RMP). The objective of the regional master plan is to ensure the timely and safe drainage of the effluent and the storm floods. The stakeholders had identified about 16 interventions, for which prefeasibility was prepared, out of which five interventions were found to be technically, economically, socially, and environmentally feasible and sustainable. Accordingly this report presents the details of the five core projects for possible investment and implementation.

The report represents the expectations and aspirations of a large array of stakeholders with whom an extensive consultative process was ensured at each stage of the plan formulation. During the preparation, the problem and issues, related to the safe disposal of the drainage effluent and storm water flood, were identified with the guidance of the stakeholders, and later the needed solutions and interventions were articulated with the stakeholders to arrive at general agreement and consensus. Similarly, the stakeholders were consulted to shortlist and prioritize interventions from a long list of pre feasibilities to be considered for detailed level feasibility studies. The stakeholders representing the rural and farming communities generally concurred with the findings. Similarly the stakeholders who attended the technical and policy workshops and reviewed the technical aspects were also in agreement. It was encouraging to note that the investment plan earned wider agreement and appreciation.

We would like to place on record our appreciation for the guidance and support extended by Engineer Ehsan Leghari (MD SIDA), Nazir Essani, Habib Ursani and yourself in the preparation of this report. We would also like to place on record the support provided by Mr. Fateh M. Mari, PhD, Project Coordinator, PCMU, and Engineer Ylli Dedja, PhD, FAO Project Management Consultant (PMC/A), and Mr. Mohammed Ehsan, The World Bank Consultant. We would also like to express our gratitude to the Special thanks are due to the PoE for their instructive comments. We take this opportunity to acknowledge the encouragement and guidance received from the Chairman PoE, Dr. Asad Kazi, and Mr. Idrees Rajput, the former Secretary of Irrigation. We are also thankful to Senator Taj Haider for his valuable advices and Perveiz Ahmed Banbhan (AMT SIDA) for excellent coordination.

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We would also like to mention here the appreciation and concurrence of the President of Pakistan on the perspective plan, who desired that the people of Sindh do not undergo this level of misery, in the event of similar unprecedented rainfall.

Sincerely yours,

Assuring our best services and cooperation,

Carlos A. Gandarillas,
Team Leader

Acronyms

AWB	Area Water Board
B/C	benefit cost ratio
C	celsius
CDM	Clean Development Mechanism
cfs	cubic feet per second
CO	community organization
DPOD	Dhoro Puran outfall drain
ENMD	East Nawabshah main drain
ETo	evapotranspiration
FGW	fresh ground water
FO	farmers' organization
GoS	Government of Sindh
ha	hectare
IAC	Indus Associated Consultants Pvt.
IRR	internal rate of return
IUCN	International Union for Conservation of Nature
Km	kilometer
KPOD	Kadhan Pateji outfall drain
LBG	Louis Berger Group Inc.
LBOD	Left Bank Outfall Drain
MD	Managing Director
MDP	Metrological Department of Pakistan
M&E	monitoring and evaluation
MH Dhoro	Meharabpur Hussainabad dhoro
mm	millimeter
MMD	Mirpurkhas Main Drain
NGO	non government organization
NPV	net present value
NTW dhoro	Nangreja Talpur Wada dhoro
O&M	operation and maintenance
PDMA	Provincial Disaster Management Authority
PMU	project management unit
RD	reduced distance
REDD	Reducing Emission from Deforestation and Forest Degradation
RO	reverse osmosis
Rs.	Pakistan rupees
SCARPs	Salinity Control and Reclamation Projects
SCDA	Sindh Coastal Development Authority
SFD	Sindh Forest Department
SGW	saline ground water
SIDA	Sindh Irrigation and Drainage Authority
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
WAPDA	Water and Power Development Authority
WASA	Water and Sanitation Authority
WSIP	Water Sector Improvement Project Phase I
WWF	World Wildlife Fund for Nature

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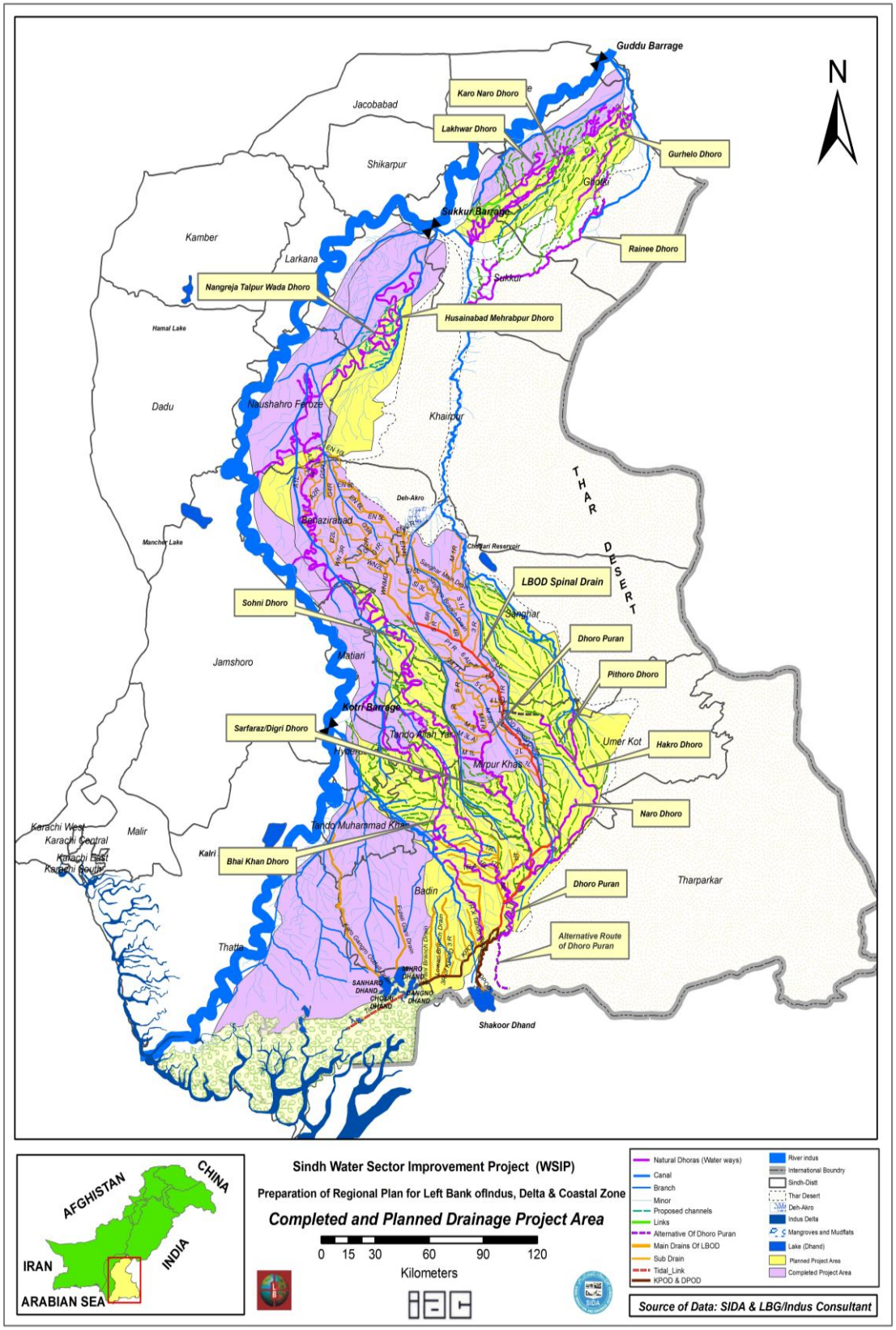

EXECUTIVE SUMMARY

Regional Master Plan Study Area

Sindh Province has a vast irrigation and drainage network and it is one of the primary beneficiaries of the Indus basin irrigation system, one of the largest contiguous irrigation systems in the world. Of the 14 barrages on the Indus, Sindh has three that divert about 48 million acre feet or 59 billion cubic meters of water annually to 14 main canal commands. These canal systems have an aggregate length of 13,325 miles or 21,445 km, and serve a gross command area of about 14.4 million acres or 5.8 million ha. There are also about 42,000 watercourses (tertiary channels), which have an aggregate length of about 75,000 miles or 120,000 km. About 78% of the area in Sindh is underlain by saline groundwater which is unsuitable for irrigation and other uses. Surface and sub-surface drainage systems are inadequate, resulting in much of the drainage effluent being either retained in the basin or disposed of into rivers, canals, and drains. There are 13 existing surface drainage systems in Sindh, which serve a total area of over 6.2 million acres or 2.5 million hectares and have an aggregate length of about 3,800 miles or about 6,100 km. In addition, there are two sub-surface drainage systems which serve an area of 100,000 acres or 40,000 ha.

Due to an inadequate drainage network and the flat topography of the basin, nearly one-fifth of the canal command area is affected by water logging and salinity. To help address the problems of water logging and salinity, the Left Bank Outfall Drain (LBOD) was completed in 1997. LBOD collects drainage water from the three districts of the Sukkur barrage command area, Shaheed Benazirabad, Sanghar, and Mirpurkhas, and drains to the sea through Badin district through a tidal link drain. LBOD has performed well and the upper part of the LBOD area has benefited from the drainage. However, there are several issues unresolved in Badin district and the coastal zone. The project study area includes all areas in Sindh Province lying on the left bank of the Indus River, including the river delta, associated wetlands, and the coastal zone. It covers the irrigation areas served by the Indus River canals off-taking from the left bank of Guddu, Sukkur and Kotri barrages, the area served by LBOD, and the extended area served by natural waterways or dhoros/dhoras that drain off rainstorm water. The 15 districts included in the study area are Ghotki, Sukkur, Khairpur, Naushahro Feroze, Shaheed Benazirabad, Sanghar, Mirpurkhas, Umerkot, Matiari, Hyderabad, Tando Muhammad Khan, Tando Allah yar, Tharparkar, Badin and the left bank of Thatta.

Rationale

The rationale for the regional master plan (RMP) is anurgent need to reduce flood damage and loss of life by improving the disposal of drainage and flood water in the Indus River left bank area. The area experienced major flood damage during floods in 2010-2012 and climate change is expected to increase the probability of extreme weather events. As expressed by the stakeholders in the area, there is a pressing need to rehabilitate the existing LBOD drainage infrastructure and to expand the drainage area from 4 districts to 15 districts by reviving the natural drainage system of dhoros, many of which are blocked and degraded, and building new surface storm water drains. In this way, many more people and a greatly expanded area will benefit from drainage services. Water logging and salinity will also be reduced with the expanded drainage system, as witnessed by the stakeholders after the operation of LBOD in the canal irrigated areas.

Impact and Outcome

The impact of the RMP will be reduced flood damage to agriculture, physical and social infrastructure, human lives, livestock, and fisheries in the Indus left bank area. The impact can be assessed in the longer term, say 20 years. The outcome will be improved disposal of drainage and flood water in the Indus left bank area. The outcome from the successful implementation of the RMP can be evaluated after the 6-7 year implementation period. As a result, the drainage area and the number of beneficiaries will be increased by over 3-fold, from about 1.7 million acres to 5.5 million acres and from about 6.3 million people to 21 million persons.

Proposed Investment Plan

As a result to the extensive stakeholder consultation process during phases I-IV of the study, 16 proposed projects were identified and pre-feasibility studies were conducted, that included the rationale, challenges, costs, implementation arrangements, economic and financial benefits, and environmental and social safeguard measures. Also, three position papers were prepared. After numerous meetings and consultations, the detailed feasibilities for each were conducted and presented at provincial and district stakeholder workshops in 2012. During the course of preparation of the pre-feasibilities, the unprecedented rains and floods in 2011 provided an opportunity to monitor the performance of the drainage system to cope with the strain and weaknesses in the system and the extent of flood damage. This enabled the Consultants to closely evaluate the systems' capacity and identify alternatives and interventions to ensure the safe disposal of storm water in the event of future climatic or natural events.

As a result of the detailed feasibility analyses, five investment projects were identified that met the criteria of sustainability, high economic return, and high likelihood of being implemented as designed. The five proposed projects include i) rehabilitation of LBOD, ii) revival of natural waterways and storm drains, iii) mangrove plantation in coastal areas, iv) rehabilitation of Deh Akro II and Chotiari wetlands, and v) forest plantation using drainage water (pilot).

The Investment and Financing Plan

The total cost of the seven year project, is estimated at about Rs. 100 billion (equivalent of about $1.0 billion), of which the base cost is about Rs.79,777 million ($798 million), and the rest is price and physical contingencies. The estimated cost of the component /subcomponent investment is in Table 1. These estimates include about Rs.9,000 million that has been spent during the last two years. Nonetheless, including this anomaly, the year wise investment requirement is presented in Table 2:

Table 1: Estimated Base Costs, and Physical & Price Contingencies for Various Components & Subcomponents

	Components /Subcomponents	Rs Million*	$ Million	% of Base Cost	% in Total Cost
1	Rehabilitation of LBOD	15,802	158	19.8%	15.8%
2	Revival of Water Ways	35,754	358	44.8%	35.8%
3	Construction of Storm Water Drains	25,310	253	31.7%	25.3%
4	Mangrove Plantation	1,319	13	1.7%	1.3%
5	Rehabilitation of Deh Akro II and Chotiari Wetlands	382	4	0.5%	0.4%
6	Forest Plantation Using Drainage Water	304	3	0.4%	0.3%
7	Performance Monitoring	906	9	1.1%	0.9%

	Components /Subcomponents	Rs Million*	$ Million	% of Base Cost	% in Total Cost
	Total Base Cost	**79,777**	**798**	**100.0%**	**79.8%**
1	Physical Contingencies	12,307	123	15.4%	12.3%
2	Price Contingencies	7,922	79	9.9%	7.9%
	Total Project Cost	**100,006**	**1,000**	**125.4%**	**100.0%**
* These estimates also includes about Rs.9,000 already spent during 20011/12 and 20012/13 to reactivate dhoros.					

Table 2: Estimated Annual Funding requirement by Components and Subcomponents (Rs.Million)

Component/Subcomponents	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	Total
A. LBOD, Dhoros, and Storm water drains								
1. Rehabilitation & Improvement of LBOD	1,087	4,951	3,254	1,542	1,271	3,384	312	15,802
2. Revival of natural waterways	10,489	5,498	5,273	5,944	4,185	3,732	632	35,754
3. Left Bank surface drains	3,967	6,604	7,488	3,920	2,077	903	351	25,310
Subtotal	**15,543**	**17,053**	**16,015**	**11,406**	**7,534**	**8,020**	**1,295**	**76,866**
B. Environment Mitigation								
1. Mangrove plantation in the coastal area	42	197	211	250	250	225	143	1,319
2. Rehabilitation of Deh Akro II and Chotiari Wetland	41	103	150	58	29	-	-	382
3. Forest plantation using drainage water	56	85	78	54	31	-	-	304
Subtotal	**139**	**385**	**440**	**362**	**311**	**225**	**143**	**2,005**
C. Monitoring & Evaluation	142	135	126	126	126	126	127	906
Total Base Cost	**15,824**	**17,573**	**16,581**	**11,893**	**7,970**	**8,371**	**1,565**	**79,777**
Physical Contingencies	1,573	1,748	1,651	1,182	790	830	149	7,922
Price Contingencies	433	1,465	2,368	2,435	2,148	2,828	630	12,307
D. Total Project Cost	**17,830**	**20,786**	**20,599**	**15,510**	**10,907**	**12,028**	**2,345**	**100,006**

Implementation Arrangements

SIDA will be the executing agency for all investment projects and the overall RMP. SIDA will also be the implementing agency for the LBOD and natural waterways projects. The Sindh Forest Department (SFD) will be the implementing agency for the mangrove plantation project working with the Sindh Coastal Development Authority (SCDA) and the International Union for Conservation of Nature (IUCN). SFD will be the implementing agency for the Forest Plantation pilot project working with SIDA and the Irrigation Department. The Sindh Wildlife Department (SWD) will be the implementing agency for the Deh Akro II and Chotiari wetlands project working with SIDA and the Irrigation Department.

Benefits and Beneficiaries

The regional plan will provide drainage and reduce flood damages to about 5.5 million acres in 15 districts, from the current 1.7 million acres in the four districts currently served by LBOD. It will provide protection from flood damage to a population of about 21 million from about 6.3 million persons that are currently served by LBOD. With the rehabilitation of LBOD and extension of drainage system in the areas that presently do not have access to any drainage facilities, the evacuation time of the storm water will be reduced from three months in a normal flood year to about two weeks. The drainage system and timely evacuation will ensure minimum disruption to access to social services (particularly health and education), availability of fodder for animals, incidence of water borne diseases, and, uninterrupted livelihood activities. It will also revive the fish production in the water bodies, and create overall economic synergies.

The projects on mangroves, forest plantations using drainage water, and wetlands will also benefit both the environment and local inhabitants that are dependent on these

natural resources. Use of participatory approaches in project design, implementation, and monitoring will help ensure that local people will benefit from the interventions.

Economic Viability

The economic viability of the core interventions is presented below, with associated estimated NPVs at 12%, switching values and sensitivity index. The table shows that all the interventions are economically viable, and resilient to the changes in the increase and decrease of benefits and costs respectively.

Table 3: EIRR, Net Present Values, and Switching Values

Components	EIRR Base Case	Switching Values			NPV at 12% Rs. million
		Reduced Benefits	Increased Costs	Simultaneous Change	
Rehabilitation of LBOD and Revival of Natural Waterways, and Storm Water Drains	16.9%	33.0%	49.055.6%	19.5%	25,505
Mangroves Plantation in Coastal Areas	17.9%	47.5%	>50%	31.0%	601.2
Forest Plantation using Drainage Water (Pilot)	24.0%	57.3%	>50%	39.9%	253.6

-Economic analysis of the Deh Akro II and Chotiari Wetlands Project was not conducted.

The EIRR of the two core projects, i) rehabilitation of the LBOD, and ii) revival of the dhoros along with the construction of the storm water drains have been estimated as one complementary intervention. Notwithstanding the benefits from the three subcomponents are not equal, and not commensurate with the individual investment outlays, as it is difficult to isolate the individual contribution, the benefits and the cost of the three subprojects have been evaluated as one investment option. However, if the benefit is assumed equal, it would be worthwhile to give higher priority to the rehabilitation of LBOD, along with the reactivation of the dhoros located in left bank of the LBOD system (so that the offloading pressure on the LBOD is achieved). This can be followed by the reactivation of dhoros located on the right side of the LBOD, and construction of storm water drains in the leftover areas within the left bank of Indus.

A INTRODUCTION

1 Background

This is the draft final report for the preparation of the regional plan for the left bank of Indus, delta, and the coastal areas, referred to as the Regional Master Plan (RMP), submitted to the Sindh Irrigation and Drainage Authority (SIDA), Government of Sindh (GoS). This report presents the feasibilities of the structural and nonstructural interventions selected by the stakeholders through a consultative process that included identifying the problems and issues, deliberating the solutions, and selecting interventions based on technical feasibility, social acceptability, financial and economic viability, environmental impact, and long-term sustainability. The report also outlines a phased investment plan, and details of the selected core projects that were identified and prioritized in consultation with the stakeholders. This report is being submitted as the Phase IV of the RMP study, and includes detailed designs and documents for the core projects as the final deliverable.

The RMP is a subcomponent of the Sindh Water Sector Improvement Project Phase-I (WSIP-I). WSIP-I has five components: i) community development and capacity building; ii) improvement of the irrigation and drainage system; iii) management plan for irrigation and drainage; iv) monitoring, evaluation, and supervision of the environmental management plan; and v) project coordination, monitoring, technical assistance and training. One of the subcomponents of component iii) is the preparation of regional plan to deal with floods and drainage issues on the left bank of the Indus River and designing measures for improvement of the Indus delta and the coastal zone. WSIP-I is a six year project, with funding support from the World Bank that started in December 2007 and will be completed in April 2013. The main objectives of WSIP-I include: i) strengthening and fast tracking the institutional reforms that are already underway in Sindh; ii) improving the irrigation system in a systematic way covering key hydraulic infrastructure, main and branch canals, and distributaries and minors; and iii); enhancing the long term sustainability of the irrigation system through participatory irrigation management and developing institutions for improving operation and maintenance (O&M) of the system and cost recovery.

The RMP study area includes the left bank of the Indus River, including the river delta, associated wetlands, and adjacent coastal zone. In particular, it covers the irrigation areas served by the Indus River canals off-taking from the left bank of Guddu, Sukkur and Kotri barrages, the area covered by the Left Bank Outfall Drain (LBOD), the area served by the natural drains, and the coastal area. See map 1.

2 Regional Plan Objectives

The main objective and scope of the RMP is to address the flood issues and prepare a plan and investment projects to provide adequate drainage to the area on the left bank of the Indus River through appropriate structural and nonstructural measures, including remedial measures for any outstanding deficiencies in the LBOD system; measures for the safe disposal of drainage, storm and flood water, and improvements of the environment and ecology in the left bank wetland and coastal mangrove areas. The RMP was designed to be completed in four phases, and involved extensive participatory consultations with a wide array of stakeholders and communities in the study area, including villagers, community groups and leaders, government staff at all levels, NGOs, and other decision makers in identifying issues and solution options, prioritizing

interventions, and participating in the planning, designing, and implementation stages.

3 Methodology

Following the submission of the Phase 1 study report in December 2010, the Consultants (LBG and IAC) prepared pre-feasibility studies based on 19 interventions proposed by the stakeholders. This was based on a review of available studies, field studies, surveys, procurement of satellite imagery, and numerous workshops, meetings, and consultations with the stakeholders at each phase of the study. The draft pre-feasibilities that were technically feasible and economically viable were presented to the stakeholders, along with the selection criteria, at the district and area water board (AWB) levels. Based on feedback from the stakeholder workshops, 19 pre-feasibilities were presented at the national stakeholder workshop on 14 January 2012 in Karachi. The participants agreed with the Consultants selection and suggested to submit the pre-feasibilities for detailed design and final selection of the proposed interventions.

During the course of preparation of the pre-feasibilities, the unprecedented rains and floods in 2011 provided an opportunity to monitor the performance of the drainage system to cope with the strain and weaknesses in the system, and its damage to human lives, agriculture, livestock, private property, irrigation, drainage, and physical infrastructure, as well as the effect on flood displaced persons including their access to social services and livelihoods. This enabled the Consultants to closely evaluate the systems' capacity and identify alternatives and interventions to ensure the safe disposal of storm water in the event of future climatic or natural events. During the preparation of the report Consultant resources were reallocated to provide support and assistance to SIDA and the Core 5 Engineers, and provide information and analysis to the irrigation department and senior politicians, including the President and at the provincial Cabinet level. This also included preparation of a plan of emergency works to restore the capacity of the drainage system, and measures to ensure safe disposal through natural waterways in the event of similar rains.

During phase-III of the RMP study a number of diagnostic and design related surveys and investigations in 12 major categories were undertaken as inputs to the preparation of the feasibility studies and assessment of the likely impacts of the proposed interventions. These included i) a physical condition survey of the drainage system and outfall structures; ii) surveys to monitor the discharge levels in the main and outfall drains to estimate actual flows; iii) a farm household damage assessment from rainfall events and farm budgets; iv) water quality monitoring in the drains affected by sugar mills affluent and pollution, and in about 100 water bodies used for drinking by people and livestock; v) land acquisition and resettlement surveys along the natural waterways (dhoras or dhoros) covering all the likely affected people (census) to document the value of land to be acquired, standing crops, household effects, and means of livelihood; vi) topographic surveying of selected representative sites of the dhoras and the full length of the LBOD to establish construction bench marks, to record the cross sections and long section measurements, earthwork requirements, profile plane, and to prepare the detailed topographic maps and overall natural features to locate the main structures; vii) geotechnical investigations at representative sites where main structures are proposed along the dhoras and LBOD, including the tidal check structures; viii) SCARP tubewell surveys in both saline and fresh water areas including functional and nonfunctional tubewells that need to be rehabilitated, repaired, and replaced (see Appendixes 23); ix) environmental assessments of all the proposed feasibility study interventions (see

Appendix 19); x) poverty assessments; xi) socio-economic studies; and xii) social impact assessments (see Appendix 20).

4 Stakeholder Consultations and Workshops

During the first phase of the study, about 750 persons participated in 19 workshops. In addition, several surveys were conducted along LBOD. In 148 villages, 5,464 participants were interviewed, including LBOD physical condition survey (3,689), environmental assessment (846), poverty assessment (296), and socio-economic survey (633). The objective was to solicit the perceptions about issues related to the safe disposal of drainage, flood and storm water, and the impact of drainage infrastructure on the environment, poverty and livelihoods.

During the second phase of the study, 12 workshops were organized at the district level, 3 at the AWB level, and one at the provincial level. The Consultants supported by 15 local partner NGOs and a consortium of 6 organizations/NGOs, organized major stakeholder workshops at the provincial and district levels, attended by 3,613 participants, of which 870 were women. In addition 6 TV programs were held for wider dissemination and feedback. In these workshops, stakeholders were encouraged to express their aspirations, apprehensions, possible solutions and interventions. Based on the stakeholder consensus and agreement, 16 interventions were selected for preparing the pre-feasibilities. The conceptual outline of the selected pre-feasibilities was presented in a regional/national workshop, held on 14 January 2012 in Karachi, for the final selection and approval of the stakeholders. Appendix 21 presents the details of the consultative process, during all phases of the study. The total number of participants in the various workshops held during the two phases was 9,077, of which female participants were 2,455 (about 27%).

Based on the participatory approach, during and after the 2011 storm water floods, the socio-economic team visited each district in the project area, assessed the situation and consulted with the flood affected communities. The team visited 89 villages in 15 districts and consulted with 1,740 persons in order to assess the losses/damages of villages, crops destruction, people and livestock affected, chickens and fish farms destroyed, diseases spread, government/private assistance provided, sources of income available, etc. In each district, the team had a partner NGO that provided first hand information about the situation on the ground, suggested villages and communities to be visited and accompanied Consultant team on each visit.

The focus of phase III consultations and workshops was on the natural and associated storm drains proposed for revival and construction. The objective was to assess the socio-economic conditions of the beneficiaries who would be affected by the development process and proposed revival of natural dhoras, to assess the level of community involvement and kind of support of the beneficiaries and to assess the benefits and negative impacts of the proposed interventions. The team conducted interviews and meetings at 10 dhoros and proposed new storm drains covering 543 households from 91 sampled villages of 32 talukas and 7 districts. A total of 2,815 people were consulted including 1,482 women. In order to foster and enforce the ownership of the RMP, informal sessions were also conducted with local people, notably community leaders, influential political persons, landlords, and civil society leaders.

During the RMP preparation in all four phases, over 14,600 persons were involved in interviews, consultations, meetings, and workshops, including visits to 326 villages, over 40 workshops, and 6 training events. The stakeholders included government officials,

politicians, community leaders, villagers, and representatives of different institutions and NGOs, media, universities, and the private sector. Details are in Appendix 21.

5 Report Outline

The main report is presented with an executive summary, introduction, regional plan context and rationale, proposed investment plan, benefits and analyses, and conclusions and recommendations. There are 23 appendixes and several attachments with the details of the RMP that satisfy the Consultants' terms of reference.

B REGIONAL PLAN CONTEXT AND RATIONALE

1 Regional Plan Issues and Strategies

The organizational strategy of the left bank of the Indus River, delta, and coastal zone consists of a shared vision among the stakeholders that looks at the improvement and development of the drainage network in the long term. The strategy was developed jointly by the Consultants, SIDA, and partner NGOs and involved a consultative process that emphasized the active participation of stakeholders from all study areas and at all levels of society, economy, and government.

The consultation process took place in three phases. The first phase focused on diagnosis, in which the stakeholders defined the fundamental issues and problems they face in their daily lives. In the second phase, stakeholders were consulted again to validate the proposed strategies and determined the priority of the possible actions. In the third phase, the focus was on stakeholders' perceptions of the problems, issues, and possible solutions to the natural drains or dhoros that had been left out of earlier LBOD drainage plans. In this way, high priority interventions were identified, thus building from a systemic approach and achieving a participatory consensus that formed the basis for the proposed RMP strategy. The strategy seeks to ensure safe and timely disposal of drainage effluent and storm water, reduce flood damage and deaths, reduce water logging and salinity, and improve local environment and ecology.

Over the last 25-30 years, Sindh has experienced numerous extreme weather events, both localized and widespread, and riverine and storm water flooding. The unprecedented rains of 2011 exposed the inadequacy and inability of the drainage infrastructure to cope with the massive runoffs. This resulted in losses of life, substantial damage to urban and rural property and infrastructure, public utilities, and agricultural crops and lands. The main causes were heavy rains in most of the drainage basins, deferred maintenance of the drainage network, encroachments and obstructions in natural waterways, and uninterrupted river water flows into the canal irrigation system and led to ponding or trapping of water and very slow flood drainage. Despite the major investments in flood protection, there is still a considerable flood hazard. It is estimated that the total losses from floods in 2011 were Rs.454 billion with about 500 lives lost. Details of the RMP area, current situation, and ordinances related to the RMP design and implementation are provided in Appendixes 2-4.

In developing the proposed regional plan strategy, the Consultants followed an extensive stakeholder consultative approach, and organized workshops at community, district, and regional levels to register their perceptions about the drainage disposal related issues and problems, and to solicit their perceived solutions and aspirations and identification of priority interventions. The findings were disseminated widely through print and electronic media for wider awareness and feedback. Based on this, several pre-

feasibilities were prepared and prioritized in consultation with stakeholders, and this lead to the formulation of the regional plan and an implementation plan. The main objectives or pillars of the proposed strategy are i) safe and timely disposal of surplus drainage effluent and storm water flood; ii) combating water logging and salinity in non-LBOD areas; iii) environmental mitigation; and (iv) creation of viable livelihood opportunities.

2 Flood Impacts

Fifteen major floods have impacted Pakistan since 1947 causing significant human and economic losses. In the last decade, the major floods experienced in Sindh were in 2003, 2006, 2007, 2010, 2011 and 2012. Details of these flood events are in Appendix 5.

During the monsoon of 2003, the LBOD project area of Badin was the worst affected area. In addition to the water drained into LBOD through the provided inlets, farmers made illegal relief cuts in drains to evacuate the water from their fields. During that time the irrigation canals were flowing at maximum capacity and farmers reacted by closing the irrigation outlets, forcing the authorities to release irrigation water into LBOD. Among the actions taken as a result of the flooding was the lowering by 2.5 feet of the DPOD weir near RD-159 of the KPOD drain.

The monsoon rains of 2006 in lower and central Sindh were among the largest recorded in the last 42 years in the districts of Sanghar, Mirpurkhas, Umerkot, Badin, Thatta, Hyderabad, and Matiari. The late southern monsoon in September was of severe to moderate intensity. Proper coordination between the concerned agencies including Pakistan Metrological Department were taken and the impacts of the rains on the LBOD system were severe to medium nature.

In 2007, two tropical cyclones developed in the Arabian Sea that passed at a distance of about 200-700 km from Pakistan. However the influence of these caused severe rains in coastal areas of Thatta, Karachi and Balochistan. Only minor damages were reported to Kotri Barrage, the surface drains and irrigation canals of Thatta district, and temporarily displacement of the coastal communities in Thatta and Badin.

In July and August 2010, widespread heavy rains resulted in high runoff in the Kabul, Swat, Chenab and Indus Rivers. The Tarbela dam flood peak was the highest value in its history, but still lower than its design capacity. The flood peak at Chashma barrage was also the highest on record and higher than the design capacity of the barrage. The flood peak at Kotri barrage was also higher than its design capacity. The 2010 flood peaks at Kalabagh, Guddu and Sukkur were lower than their historical peaks and lower than their design capacities.

The late monsoon of 2011 will be remembered for its remarkably high rainfall in Sindh, particularly in the left bank of the Indus. The cumulative rainfall varied between 423 mm to 1,143 mm. As the gradient of the coastal areas is near zero, the disposal of the runoff was problematic causing inundation and stagnation of the storm water. Blockages and encroachments in the natural drains and infrastructure such as railroads, roads, canals and drains also inhibited the drainage. The evacuation of the storm water was further compounded by numerous breaches in the irrigation and drainage network. Significant amounts of crops and livestock were lost and there was major damage to the productive, physical, and communication infrastructure. About 500 people succumbed to the floods. According to the Provincial Disaster Management Authority (PDMA), about 38,500 villages and 9.3 million people were affected, and about 1.6 million houses were fully or

partially damaged. The estimated flood damage was Rs.454 billion.

Towards the end of the monsoon season in 2012, recorded rainfall in northern Sindh was exceptional. Jacobabad experienced a 24-hour rainfall event with a return period of more than 100 years. This caused severe flooding and drains were filled beyond their design capacities. As in other flooding events, the farmers made illegal relief cuts to irrigation channels to drain their fields and tractor driven pumps and electric pumps were used to pump water into irrigation channels. This exacerbated flooding in the tail reaches. About 4,000 villages were affected and over 80,000 houses were destroyed or damaged.

3 Analysis of Key Problems and Stakeholder Feedback

The participatory consultative approach was used throughout all workshops, meetings, consultations, and surveys with stakeholders. The stakeholders were given detailed presentations on the issues and problems identified during the first phase of the study. Based on the findings, the Consultants and stakeholders in the second phase of the study identified several interventions to address the issues and problems in the study area, and are summarized in the Table 4. Stakeholder consultation details are in Appendix 21.

Table 4: Issues, Problems and Proposed Solutions

Issues and Problems	Proposed Interventions
1. Rehabilitation of LBOD Drainage Infrastructure	
Major problems include overflow of storm water in KPOD; flooding and ponding in Badin; and tidal effects in KPOD, Badin and coastal lakes.	Rehabilitate all LBOD systems, raise banks of KPOD, remodel DPOD for 4,000 cfs flow, and provide tidal outfalls on KPOD to check tidal effects
2. Revival of Natural Waterways To Drain Out Storm Water	
The blocking of natural waterways (dhoros) results in the ponding and delayed drainage of storm water floods causing considerable damage to standing crops, private property, and infrastructure.	Revive dhoros, remove illegal blockage and encroachments, and provide bypasses to protect urban settlements and structures. Also, facilitate timely drainage of storm water with new drains in the leftover areas not served by LBOD
3. and 4. Rehabilitation of SCARP Tubewells (in both saline and fresh groundwater areas)	
The performance of SCARP tubewells is abysmal as more than 82% of tubewells are non-operational and the parts have disappeared. This has increased water logging and salinity.	Repair and replace SCARP tubewells in both saline and fresh groundwater areas and ensure their operation and maintenance. Private tubewells in fresh water areas can be encouraged with subsidies.
5. Ghotki SCARP (Saline Zone)	
A project was prepared by NESPAK/WAPDA that stakeholders believe can control the rising water table and increase farm productivity.	Assess the current situation and update the existing feasibility report and make recommendations accordingly, if the project is feasible.
6. Second Line of Defense for the Left Bank of Indus	

Issues and Problems	Proposed Interventions
Communities along the flood protection bunds (embankments) feel vulnerable to floods and other natural events.	Instead of additional bunds that would involve land acquisition and resettlement, stakeholders prefer strengthening the original bund.
7. Elevated Platforms for Flood Displaced Persons	
There is a lack of higher ground for taking refuge by marooned communities.	Elevated platforms or widened sections along the existing roads and canal bunds would also help in finding refuge from flood waters.
8. Rehabilitation of Coastal Wetlands	
Failure of the Cholri weir and the tidal link and breaches in the bunds have turned dhands into sea water lakes; and wetland birds, fish, and plants have largely disappeared and livelihood opportunities for local people have been reduced	Dhands could be surrounded with bunds and mangroves to minimize erosion from rains and tides, and storm water from KPOD can flow into dhands, enabling a revival of fish, reed grass for the livestock, and migratory birds and water fowl.
9. Protective Plantation of Mangroves in the Coastal Areas	
Sea water intrusion is damaging crop lands and fresh water bodies and eroding coastal areas; and mangrove cutting has reduced fish catches.	Increase mangrove and salt resistant plant nurseries and plant mangroves to protect wetlands, reduce sea water intrusion, and increase fuel wood and fish spawning
10 Use of Drainage Water for Forestation in LBOD and Kotri Areas	
Deforestation is causing degradation of ecosystems and reducing productivity of forests and farmlands, and there is a lack of participatory approaches used with farmers.	Provide drainage water for forestation close to the LBOD and supplement drainage water with fresh water. Provide farmers with tree saplings and extension advice.
11. Biosaline Agriculture in Badin and Thatta Districts	
Water scarcity and drought below Kotri barrage has adversely reduced agriculture and livelihood opportunities and increased desertification.	Bio-saline agriculture can grow salt tolerant food and fodder crops, bushes and trees that will reduce soil salinity and provide livelihoods.
12. Rehabilitation of Deh Akro II and Chotiari Wetlands	
The wetlands are severely threatened with water scarcity and losses to the wildlife and economy. Seepage from the Chotiari reservoir is causing water logging and salinity in farm land.	Wetlands can be revived with assured supplies allocated from the Nara canal system, and drain outside Chotiari reservoir bund with interceptor drains can reduce seepage.
13. Shrimp and Mud Crab Farming in the Coastal Areas	
Depleted fish resources in the coastal area has reduced livelihood	Shrimp and mud crab production can be promoted with credit and extension services.

Issues and Problems	Proposed Interventions
opportunities and increased poverty.	
14. Brackish Water Fish Farming in LBOD Area	
Livelihoods for fishermen of the area have declined due to degradation of fisheries resources and pollution.	Construct fish ponds on private land and provide credit and training to farmers and establish brackish water fish hatcheries.
15. Establishment of Disaster Management Cell in SIDA	
Lack of community awareness on preparing and coping with floods and climatic events, and no advance warning along LBOD and dhoros.	A disaster management cell in SIDA can prepare and coordinate plans for emergency response and provide training to SIDA staff who will train communities.
16. Gender Mainstreaming In Irrigation and Drainage	
The enabling environment for women's active role in water management is missing, and SIDA, AWB, and FOs need to be made aware of gender sensitivities.	Strengthen SIDA's social section to organize training courses to sensitize the stakeholders and increase women's participation.
17. Drainage Effluent Intrusion in the Ghotki Area from Southern Punjab	
Drainage effluent intrusion from Southern Punjab into the Ghotki area is causing degradation of land.	Identify mitigation options and actions to be taken at the intergovernmental level.
18. Sugar Industry Effluent Treatment at Source	
Sugar mills are illegally dumping untreated toxic pollution into LBOD drains. EPA is ineffective in regulating sugar mills to treat effluent and reduce pollution.	Several available technologies can be used to treat the polluted wastewater at source. EPA can be strengthened and empowered to regulate sugar mill pollution and enforce penalties.
19. Access to Potable Water in the Left Bank	
Surface water is main source of water for drinking and household use but is highly polluted (less than 8% of wastewater is treated). Ground water is saline and often unusable with high mercury levels.	Village treatment facilities for surface water can be provided free or at subsidized rates. Where ground water is brackish and the only source of drinking, treatment technologies are needed at subsidized rates.

4 Rationale and Lessons Learned

The rationale for the RMP is the urgent need to reduce flood damage and loss of live by improving the disposal of drainage and flood water in the Indus River's left bank area. The area experienced major flood damage during floods in 2010-2012 and climate change is expected to increase the probability of extreme weather events. As expressed by the stakeholders in the area, there is a pressing need to rehabilitate the existing LBOD drainage infrastructure and to expand the drainage area from 4 districts to 15 districts by

reviving the natural drainage system of dhoros, many of which are blocked and degraded, and building new surface storm water drains. In this way, many more people and a greatly expanded area will benefit from drainage services. Water logging and salinity can also be expected to be reduced with the expanded drainage system, as witnessed by the stakeholders after the operation of LBOD in the canal irrigated areas.

Some of the lessons learnt from previous drainage projects in Sindh and particularly from the 2011 flood include:

a. Under Designed Drainage Network

The existing drainage infrastructure was designed for 5 year return period and for a rainfall of 125 mm to be evacuated in 5 days. The last two decades have witnessed more frequent high rainfall events and flood disasters. The intensity of the 2011 rains was unprecedented; about 5 to 6 times higher than the design capacity of the drainage system. There is a need to remodel and rehabilitate the existing drainage infrastructure on a 20 year return period basis to enable the system to timely and safely dispose of high intensity storm water flows.

b. Deferred Maintenance of Irrigation and Drainage Infrastructure

The stakeholders complained that the drains are clogged with weeds and silt, and the banks have numerous rain cuts and deliberate relief cuts by farmers during previous rains which were not fixed. This increases the vulnerability and risk of breaches, which were witnessed during 2011 floods.

c. Encroachment in the Natural Waterways

The major cause of delays in the disposal of flood and storm water was the obstructions in the natural waterways or dhoros. These dhoros used to be operational before the construction of the LBOD system. The blockades include unauthorized construction of earthen, adobe and brick walled structures, infrastructure, and crops. It was also observed that the inadequate size of the drainage outlets and culverts also caused ponding of flood water in the depressions that could not be evacuated due to blockages all around. Adequate drainage outlets, culverts, bridges, waterways, etc. are required to facilitate the quick disposal of flood water. In addition, intersecting roads, bridges, settlements, and the LBOD spinal drain further constrict storm water flows, and siphons and bypasses are needed to facilitate the storm water flows through the dhoros. The GoS has recently enacted legislation in this regard, and it needs to be enforced and complied with.

d. Delayed Closure of Irrigation Canals

It was noted by stakeholders and the Consultants that despite the early warnings of the extreme rain event in 2011, the irrigation canals remained open and delivered regular irrigation water. This resulted in about 55 reported breaches in canal system while heavy rain continued generating high storm water flows. The combined effect caused widespread canal and drain breaches and flooding. The Meteorology Department and others responsible for disaster management should immediately and widely disseminate extreme weather event warnings and canals should be closed before these events.

e. Absence of Trigger Mechanisms for Disaster Management

The absence of a coordinated flood preparedness plan by the line agencies is a major concern. Due to the absence of trigger mechanisms to provide rescue, relief and rehabilitation to affected persons and areas, timely support could not be provided. Coordinated efforts by PDMA, the departments of Irrigation, Food, Health, Local

Government, Education and Agriculture, the Pakistan Army, district governments, and local and international NGOs are needed to develop preparedness strategies to face such natural calamities.

f. Perceptions of Stakeholders in Southern Districts

Since its construction, a sizeable population of Badin and Thatta districts and the coastal areas has maintained that the LBOD drainage network has brought significant miseries to them. They believe that priority was given to improving the productivity of Shaheed Benazirabad, Sanghar and Mirpurkhas districts at their expense. They felt that the disposal of drainage effluent has created significant negative externalities for them, and has adversely affected the productivity of farmland, fish catch, reduced livelihood opportunities, and increased poverty. They also felt that seawater intrusion and back flows in the drains have rendered their once fertile lands saline and waterlogged, and irreversibly impaired the coastal and natural resource environment. However, during extensive surveys by the Consultants after the 2011 flood, most people surveyed tacitly acknowledged that the LBOD system played a role in draining off the 2011 flood waters, as the LBOD system accommodated three times more flows than its design capacity, notwithstanding several unfortunate incidents of overtopping and breaching. They concede that without LBOD, the losses to lives and property would have been greater. Nevertheless, most communities believe that the drainage infrastructure needs to be improved to provide timely evacuation of the storm water.

5 Screening and Ranking of Proposed Interventions

Feasibilities were prepared for eight structural, six nonstructural, and two institutional interventions that were identified in the stakeholder workshops. In addition, three position papers were developed to identify problems and recommend actions. However, as a result of the pre-feasibility and feasibility analyses, only five of the proposed interventions were found to be feasible and sustainable: (i) rehabilitation of LBOD, (ii) revival of natural waterways and storm drains in the left over areas, (iii) plantation of mangroves, (iv) rehabilitation of Deh Akro II and Chotiari wetlands and reservoir, and (v) use of drainage water for forestation (pilot activity). The other proposed interventions were found to be unsustainable, economically nonviable, and high risk, and are not recommended for financing. Nevertheless, the feasibilities for these proposals are provided in Appendixes 23. The reasons for either recommending or not recommending the proposals are summarized in Table 2 below.

Table 2: Proposed Interventions, Low Priority Proposals, and Position Papers

Recommended/High Priority Interventions	**Rationale**
1.Rehabilitation of LBOD	Essential for the sustained operation of the drainage network to safely drain out the drainage effluent and storm water, and reduce seawater intrusion.
2.Revival of Natural Waterways and Storm Drains	Revival of natural water ways complemented by the storm water surface drains in the left over areas will timely evacuate the storm water during extreme precipitation events, reduce flood damage in the areas outside the LBOD network, and relieve pressure on LBOD to function as per design.
3.Mangrove Plantation in Coastal Areas	Mangroves planted near the LBOD's tidal link and nearby coastal area can help reduce salt water intrusion into LBOD, coastal lakes (dhands), and farmers' fields. They can also help reduce coastal

	erosion.
4.Rehabilitation of Deh Akro II and Chotiari Wetlands	These two major wetland systems, one a Ramsar site, are next to the Nara canal and LBOD. Improving water supply and drainage in these wetlands will help conserve endangered crocodiles, migratory birds, and other animal and plant species. Reduced seepage from Chotiari reservoir and improved drainage will reduce waterlogged areas and increase crop production.
5.Forest Plantation Using Drainage Water (Pilot)	Many farm lands within the corridor of the LBOD system are barren because of lack of water, being in the tail reaches of the irrigation watercourses. These lands can be planted with suitable forest trees using drainage water from LBOD. This is a pilot intervention because it has not been attempted in the LBOD area before.
Not Recommended/Low Priority Proposals	
1.Rehabilitation of SGW SCARP Tubewells	A survey conducted during preparation of the RMP found that about 82% of the tubewells in the saline ground water areas are not operating and need full replacement. Their operation is not sustainable.
2.Ghotki SCARP (saline zone)	The review of the 1994 NESPAK/WAPDA feasibility report found it to be unfeasible. However, we recommend that a new surface drainage network be constructed to drain storm water, and this has been included in output 2 of the project (Revival of Natural Waterways and Storm Drains).
3.Privatization of FGW SCARP Tubewells	Most of the tubewells in the waterlogged areas with fresh ground water are not operating. Their operation is not sustainable and farmers are not interested in buying these tubewells or investing in private tubewells in waterlogged areas. However, private tubewells are abundant in the non-waterlogged areas.
4.Second Line of Defense for Left Bank of Indus	Stakeholders overwhelmingly rejected this proposal and recommended strengthening the original banks. It was also found to be uneconomical.
5.Elevated Platforms for Flood Displaced Persons	This proposal was found to be expensive and unsustainable, given the low priority given to maintenance.
6.Biosaline Agriculture Development	Sugar mill effluent is polluting the drainage water and this proposal cannot be recommended until the pollution is stopped (see Position Paper 2). Also, the provision of credit facilities for farmers is unsustainable.
7.Rehabilitation of Coastal Wetlands	Tidal flows coupled with sugar mill effluent pollution currently affect the water quality of these wetlands. Interventions are expensive and unsustainable.
8.Shrimp and Mudcrab Farming in Coastal Areas	Unsustainable due to low economic returns, lack of credit facilities for farmers, and failed previous projects of this nature in the study area.
9.Brackish Water Fish Farming	Unsustainable due to low economic returns and lack of credit facilities for farmers.
10.Disaster Management Unit in	Disaster management is already being handled by the Provincial

SIDA	Disaster Management Authority and a unit in SIDA is not needed.
11.Gender Mainstreaming	The SIDA Panel of Experts recommended that the role of women in drainage rehabilitation and management is not an issue and a separate intervention is not needed.
Position Papers	
1. Drainage Effluent Intrusion in Ghotki Area	The drainage water ponds constructed by the SCARP VI project are neither socially nor environmentally sustainable, unless the volume of the incoming water from Punjab is reduced and/or the evaporation area of the ponds is increased. An inter-provincial solution should be sought.
2. Sugar Industry Effluent Treatment	The sugar mills throughout the left bank area are dumping highly toxic wastes into LBOD drains and have polluted wetlands and killed fish and livestock. Waste water treatment plants should be constructed and maintained and sugar mills charged for clean effluent.
3. Water Quality Improvement for Human Consumption	Recommendations are provided to improve the availability and quality of water filtering and treatment facilities for human consumption.

6. Proposed Prioritizing and Sequencing of Interventions

The prefeasibility studies that were prepared during phase II of the study in consultation with the stakeholders were screened, ranked and prioritized, based on a set of criteria including: technical viability, social acceptability, environmental impact and sustainability, economic and financial returns to investment, and implementation capacity and sustainability. A ranking procedure was developed and submitted to SIDA and the WISP PCMU for comments and inputs. The description and interpretation of each of the criterion and sub-attributes is given in the phase II final report. The expected impacts of each proposed intervention were either positive or negative and were classified from none to very high in a scale that ranged from 0 to +4 for the positive effects and from 0 to -4 for the negative effects. In the phase II workshops, the stakeholders' inputs were included in the evaluation criteria for the ranking. The 16 proposed interventions were then analyzed and detail feasibility studies were prepared. Based on the results of the feasibility studies (see Appendixes 9-13 and 23), the final ranking and prioritizing of the 16 proposed interventions were finalized and grouped in three categories.

a. High Priority/Core Interventions

It was proposed that given the exigency of the intervention, and considering their quantifiable and non-quantifiable benefits, five of the proposals were recommended as core projects of high priority. They include:

i. Rehabilitation and improvement of LBOD
ii. Revival of natural waterways and storm drains
iii. Mangroves plantation in coastal areas
iv. Forest plantation using drainage water
v. Rehabilitation of Deh Akro II and Chotiari wetlands

The first two have direct bearing on the aversion of flood disaster if the high rain events relapse. They are expected to ensure the timely and safe evacuation of storm water floods, and would save colossal losses and damage to standing crops, livestock, private and public properties and infrastructure, and more importantly human lives, and improve the quality of life of rural communities.

The third intervention will complement the safe outfall of the drainage effluent into the sea, protect the outfall drainage infrastructure, and reduce sea water encroachment and the adverse effects on farm land and water bodies in the coastal areas. It would also support the livelihoods of coastal communities through restoration of fish potential.

The proposed project to use a combination of drainage water and canal water to promote tree planting in the LBOD and Kotri areas will potentially create numerous environmental benefits from increased tree cover and benefits to participating farmers in the form of timber, fuel wood, and fodder for livestock. It is considered pilot or experimental in nature because it has not been implemented previously on a large scale in the study area.

The feasibility analysis for the rehabilitation of the Deh Akro II and Chotiari wetlands suggests that the main benefits are the restoration of wildlife, improvement of the ecology of the wetlands, and quantifiable benefits from intercepting seepage from the Chotiari Lake or reservoir and constructing drains and installing tubewells to reduce water logging in the adjacent farmlands. The Sindh Wildlife Department will implement the wetlands and wildlife activities, and a coordinated effort will be required to implement the intervention with SIDA and the Irrigation Department for supplying Deh Akro with freshwater from the Nara canal and for improvements to the Chotiari reservoir.

b. Second/Low Priority Interventions

The following three projects, despite their technical feasibility, are marginally economic viable. Their rates of return are not robust and are sensitive to variations in costs and benefits:

i. Bio-saline agriculture in Badin and Thatta districts

ii. Brackish water fish farming in LBOD area

iii. Shrimp and mud crab farming in coastal areas

The feasibilities of the first intervention found that the investment had a modest rate of return and was very sensitive to changes in costs and benefits. As this is not directly relevant to facilitating the timely and safe disposal of storm water and also not within the mandate of SIDA or the Irrigation Department, it may be entrusted to the Sindh Agriculture Department for possible financing.

The feasibilities of the two fish-related interventions indicate that the interventions have modest rate of return and are very sensitive to changes in costs and prices. As the proposed interventions are essentially private sector activities, the Sindh Fisheries Department could provide back up support to and help arrange financing for the interested fish farmers.

c. Interventions Not Recommended for Implementation

The following feasibilities were prepared and it is recommended that they do not merit further considerations, for the reasons mentioned below:

i. Establishment of Disaster Management Cell in SIDA
ii. Gender mainstreaming in Irrigation and Drainage (ranked 9)
iii. Privatization of FGW SCARP tubewells
iv. Rehabilitation of LBOD and SCARP tubewells
v. Ghotki SCARP - saline zone
vi. Elevated platforms for flood displaced persons
vii. Rehabilitation of coastal wetlands
viii. Second line of defence for left bank of Indus d/s Kotri

Given the magnitude of the flooding risk and the inadequate capacity of the SIDA to cope with water disasters, the need for creating an efficient disaster management cell is not recommended, and instead it is proposed that SIDA strengthen its coordination with the rescue, relief, and rehabilitation work in conjunction with PDMA.

It is proposed that to ensure the role of women in the participatory water management approach, the social cell within SIDA also assumes the responsibility of ensuring gender mainstreaming and adopts the recommendations of the feasibility study. The Consultants proposed this scheme due to numerous unquantifiable benefits of investing in the development of human resources. Numerous studies and donor organizations including the World Bank advocate women's participation to enhance efficiency: 'Women who are trained to manage and maintain community water systems often perform better than men because they are less likely to migrate, more accustomed to voluntary work, and better entrusted to administer funds honestly' (World Bank 1992: 113).

A review of the feasibility for the divestment of FGW tubewells (prepared by consultants engaged by the Irrigation Department) was undertaken to reassess and evaluate its technical and economic viability in the current situation, which suggests that the proposal is still viable. However, since the completion of the feasibility, the number of private tubewells has surged and the demand for additional tubewells has declined. Therefore the emphasis should be on divesting the existing public sector tubewells and facilitating farmers to develop their own tubewells.

Similarly, the feasibility to rehabilitate the dysfunctional and non-operative SGW tubewells suggests that the investment will have a positive payoff to water logging and salinity control. However despite its potential benefits, the sustainability of the investment is in question. It was reported by the beneficiaries and observed by the Consultants during field visits, that more than 82% of the tubewells are closed, mostly due to vandalizing of the pumps, motors, electrical fixtures, PMT, LTL, and HTL. The farmers highlighted that without adequate and sustained protection, they would again be closed down. Therefore it is considered a highly risky and unsustainable investment.

The review of feasibility of Ghotki SCARP (1994) prepared by consultants engaged by WAPDA suggested that the proposed intervention is no longer economically viable (using 2012 prices), and will have enormous negative environmental consequences, the mitigation of which will have high cost. However, the drainage situation in the Ghotki area will be improved with its inclusion in the proposed Revival of Natural Drains and Storm Drains Project whereby Ghotki dhoros will be improved and associated surface drains will be constructed.

The prefeasibility of the elevated platforms, prepared by the Consultants, suggested that the proposed intervention has a very high cost (about Rs.1.2 billion), and would provide refuge to some 20,000 families or about 100,000-120,000 people. Moreover, it would be expensive to maintain these elevated platforms when not in use. Due to the threat of unauthorized occupation for other purposes, its sustainability is extremely unlikely. However, using drainage banks, canal banks and sections of roads, if widened and strengthened, could be cost effective and would be accessible to a large number of flood displaced persons.

The prefeasibility for the rehabilitation of coastal wetlands showed that intervention will not yield enough returns to justify its investment costs, will have high risk of failure due to high magnitude cyclones, and will not be sustainable. In addition, the sugar mills effluent laden water from Karo Ghungro and Guni Phuleli drains will pollute the water and kill the local fish proposed to be promoted in dhand complex. It is not recommended.

Similarly, the second line of defence intervention was found to be technically viable, but is not socially acceptable. The communities along the proposed alignment vehemently opposed its implementation and will increase the risk of flood disasters. Therefore, it is not recommended.

C PROPOSED INVESTMENT PLAN

1 Impact and Outcome

The impact of the RMP will be to eliminate flood damage to agriculture, physical and social infrastructure, human lives, livestock, and fisheries in the Indus left bank area, unless the flood events exceed a 20 year return flood intensity. The performance indicators will include i) reduced average flood damage from Rs.454 billion estimated from the 2011 catastrophic flood to insignificant damages; ii) eliminate human deaths from floods from about 500 in 2011 to none, and iii) eliminate livestock deaths from floods from about 120,000 in 2011. The RMP performance and monitoring framework is in Appendix 1.

The outcome will be improved disposal of drainage and flood water in the Indus left bank area. The outcome from the successful implementation of the RMP can be evaluated after the 6-7 year implementation period. The performance indicators will include i) increased drainage area from about 1.7 million acres in four districts currently served by LBOD to about 5.5 million acres in 14 districts that will include both LBOD and natural and storm water drains; ii) increased beneficiaries from the improved drainage system from about 6.3 million persons to about 21 million; iii) reduced time needed to drain most rain water from 3 months in a normal flood year (such as 2012) to 2 weeks; and iv) reduced time needed to drain most rain water from 4-6 months in an extreme event (such as 2011) to 3-4 weeks.

2 Projects: Improved Drainage System

a. Rehabilitation and Improvement of LBOD

i) Description and Rationale

The LBOD network was built during 1985-2003 to dispose drainage water from the surface and tile drains, salinity control and reclamation project (SCARP) tubewells, and the storm water flows generated by runoff in the catchment area. LBOD serves a command area of about 1.7 million acres irrigated by the Rohri, Nara and Akram Wah canal systems in Shaheed Benazirabad, Sanghar, Mirpurkhas and Badin districts.

During the last 25 years, particularly in 1994, 2003, 2006, and 2011, the left bank of the Indus experienced extreme rainfall events that caused colossal damage to human lives, livestock, agriculture, stored grains, private and public property, and productive and physical infrastructure. A large segment of the population was marooned and displaced constraining their access to social services and livelihoods until the area was fully drained and they could resume their normal activities. Climatic change due to global warming and other factors is expected to bring about more frequent extreme weather conditions. The situation in the study area is further exasperated by major damage to the tidal link and the collapse of the Cholri weir, causing sea encroachment during high tides into the LBOD system and degrading large areas of productive land and inland lakes and fresh water bodies.

Box 1: Profile of Spinal Drain

Length (reduced distance RD)	662
Discharge (cfs)	1240- 4600
Bed width (ft)	85 -162
Depth (ft)	8.75 to -13.33
Side Slope (-)	1:3
Berm width (ft)	20-25
Longitudinal Slope (ft/ft)	0.000118-0.00005

The drainage system is in a dilapidated state and the existing capacity of the LBOD and Badin area drains is insufficient to drain out the storm water. Whenever the rainfall added to the normal drainage flows from the irrigation system and groundwater exceeds the designed capacity, low lying areas become flooded and the drainage period lasts days, weeks, or months. Drainage is slowed when maintenance is poor and when farmers make unauthorized breaches along the drains and irrigation canals to drain flood water from their fields. Weak drainage banks with lack of adequate free board are prone to breaches and flooding of the area. The situation is further exasperated due to the submergence of drains at the points of outfall, blocking the flows in the network and resulting in overtopping and breaches. The uninterrupted flow of canal irrigation water and canal escapes and breaches also contribute significantly to the drainage problems during and after storm events.

During August and September of 2011, most parts of the left bank of the Indus River received the highest rainfall on record of 500-1,200 mm that inundated most areas with an average depth of 3-4 feet. The heaviest rainfall in a 2-day period was 2-3 times greater than the existing capacity of the drainage system. The heavy rainfall in the Shaheed Benazirabad, Sanghar, and Mirpurkhas districts generated a runoff of about 15,000 cfs, while the LBOD system was designed for a discharge of only 4,600 cfs. During the 2011 floods, the system actually performed better than expected, despite obstructions in the system, encroachments in the waterways causing overtopping and breaching in many places, and uninterrupted canal water flows from the Indus River barrages. The high level of water in the spinal drain caused submergence of the MMD and the LBOD branch drains resulting in the inundation of adjoining villages and towns, severely damaging the life and property of millions. Many farmers made illegal relief cuts in the banks of the spinal and branch drains to try to drain the storm water more quickly from their fields. The damage to the drainage infrastructure was enormous and quite a few watercourse aqueducts collapsed and bridges were damaged.

To ensure the safe disposal of the storm water and to reduce sea water intrusion, it is recommended that the emergency works be completed, including massive desilting of the drain beds, restoration of the freeboards, repair of damaged inlets, and stone pitching at vulnerable points. It is expected that future implementation of these and other

proposed interventions would reduce the time needed to drain off storm water, reduce flood damage, and improve incomes and crop production in the longer term. In addition, the interventions are expected to reduce the negative impacts of seawater intrusion into the drainage system and improve coastal erosion. Details of the project are in Appendixes 7, 8, and 10).

ii) Project Location

The proposed project will rehabilitate surface drainage systems located in the districts of Shaheed Benazirabad, Sanghar, Mirpurkhas, and Badin.

iii) Objectives

i. To ensure safe, timely, and unconstrained disposal of drainage and storm water;
ii. to rehabilitate and improve the existing LBOD infrastructure; and
iii. to divert storm water to dhoros and desert areas under extreme rainfall events.

The main impact of the interventions will be reductions in flood damages to crops, livestock, and private and public property, and improved livelihoods of the communities and access to social services. In addition, reduction in seawater intrusion will restore the productivity of degraded lands and water bodies and improve rural livelihoods.

iv) Performance Targets

It is recommended that the following structural and nonstructural interventions be completed by the end of the project implementation period (10 years).

Table 5: LBOD Performance Targets

N^{o}	Major Targets	Start	End
1.	Restoring spinal drain (RD 815 to RD 159)	Year 1	Year 3
2.	Restoring DPOD (RD127 to RD 5)	Year 1	Year 3
3.	Restoring KPOD (RD 159 to RD 0)	Year 1	Year 3
4.	Restoring LBOD branches, KPOD, and other drains	Year 1	Year 3
5.	Restoring Mirpurkhas component surface drains	Year 1	Year 3
6.	Restoring Sanghar component surface drains	Year 1	Year 3
7.	Restoring Nawabshah component	Year 1	Year 3
8.	Restoring Phuleli Guni drainage system	Year 1	Year 3
9.	Restoring Karo Gungro drainage system	Year 1	Year 3
10.	Remodeling LBOD drainage system for return period of 20 years	Year 2	Year 6
11.	Remodeling KPOD to discharge of 6,000 cfs	Year 2	Year 6
12.	Remodeling Mirpurkhas main drain to separate from dhoro Puran	Year 2	Year 6
13.	Converting non-inspection path of spinal/main and all branch drains	Year 2	Year 6
14.	Constructing all weather road from RD 159 of spinal drain to RD 815 (131 miles)	Year 2	Year 6
15.	Providing pumps at outfall points of Badin drainage system	Year 2	Year 6
16.	Constructing new bridges and water course aqueducts	Year 2	Year 6
17.	Constructing of new inlets to support of farm drainage	Year 2	Year 6
18.	Constructing tidal control regulator at RD minus 12 of KPOD	Year 2	Year 6
19.	Planting protective vegetation to stabilize banks	Year 3	Year 5
20.	Supervision consultants appointed	Year 1	Year 2
21.	Site offices and residential quarters constructed	Year 1	Year 2
22.	Boats and vehicles procured	Year 1	Year 2

N°	Major Targets	Start	End
23.	Survey and scientific equipment procured	Year 1	Year 2
24.	Radio communication system procured and installed	Year 1	Year 2
25.	Early warning system established and operational	Year 1	Year 2

The civil works mentioned above include desilting of the drainage network, compacting and strengthening the sides and freeboards of the drains, raising the banks, and restoring damaged structures.

v) Cost Estimates

The total cost of the LBOD rehabilitation is estimated at Rs.20,220 million out of which the base cost is Rs. 15,802 million ($158.0 million).

vi) Implementation Arrangements

The short term works of emergency nature and medium term measures are to be contracted out by following the normal tendering process; while the long term interventions will follow the international competitive bidding route. It is proposed that the following actions are strictly complied with: i) the main canals systems are closed at least one week before the start of rainfall warnings; and ii) heavy earth moving machinery is mobilized at all the vulnerable points by the middle of July of every year.

vii) Safeguards

The environmental and social assessments, including the land acquisition and resettlement plan, was discussed by the Consultants in numerous consultations, meetings, interviews, and workshops with stakeholders including farmers, fishermen, rural inhabitants, NGOs, and government workers. The planned improvements in the drainage network, including the major expansions of the drainage area from the improvements in the natural drains (dhoros) and new surface storm drains in the left over areas, will have major positive impacts and no major adverse environmental impacts are anticipated with respect to ecology, habitats, cultural heritage sites, etc. The planned improvements will reduce human and livestock deaths and reduce damages to infrastructure, crops and livestock. No social or environmental adverse impacts are foreseen, but the project's success depends to a large extent on the government's capacity to enforce existing laws and regulations to control canal water entering the drainage network, pollution from sugar mills and other sources in the drains, bans on fishing activities in the drains, etc. Adequate funds for O&M of the drainage network and successful implementation of O&M are also critical.

b. Revival of Natural Waterways and Storm Drains

i) Description and Rationale

A maximum of 75,757 cusecs of water are drawn from Indus River through eight major canals off taking from three barrages, which irrigate about 8.6 million acres of land on the left bank of the Indus. Roughly 33% of irrigation supplies to crops percolates through soil and is added to underground water. Consequently the water table has risen and created water logging and salinity problems on the left bank of Indus. This problem has been further aggravated by heavy rainfall events due to global climate changes combined with inadequate or no drainage network in most of the areas. It is imperative to provide drainage to the leftover areas by reviving the dhoros and improving the efficiency of the existing drainage systems to sustain

irrigated agriculture and economic activity in the study area. The agriculture benefits to drainage are complimentary to irrigation development. The agriculture benefits include i) increased area and yield due to timely removal of storm water, ii) increased yields, iii) increased cultivated area from new lands and by reducing the area of seasonally barren lands, iv) use of drainage water to augment crop water requirement at the time of stress, v) protection of moveable and immoveable property in the project area, and vi) reduced damages to roads and other important infrastructure.

In Sindh there are many short and long reaches of the abandoned river courses on both sides of the Indus River. These abandoned river courses used to serve as natural drains (dhoros or dhoras) for river and storm water floods. Over time, the dhoros have been obstructed by unauthorized embankments, roads, canals, drains, fish ponds, cropped areas, villages, small towns, and houses. These obstructions impede the drainage of rain and flood waters, causing ponding and inundation of the standing crops, and damage to infrastructure, and loss of livestock, and human lives. The extreme rainfall event in 2011 was a wakeup call, which caused unparalleled loss to the human lives, marooning settlements, and damage to crops, livestock, physical and productive infrastructure, and communications. According to the recent report of PDMA, the estimated value of damages from the 2011 storm flood was about Rs.457 billion. It excludes the cost of relief and rescue operations and man months of staff and students lost due to prolonged stay of displaced persons in schools and official buildings.

To address this issue, the Consultants evaluated the possibility of reviving and improving the dormant dhoros to ensure safe disposal of flood waters. A number of potential dhoros were identified, including Karo-Naro, Gurhelo, Lakhwar, Rainee, Hussainabad-Mehrabpur, NTW in Khairpur, Sohni, Bhai Khan, Puran, Digri/Sarfraz, Hakro, Naro, and Pithoro. To mitigate the situation, revival of these natural water ways is critical. The reactivation of these dhoros would not only help dispose off storm water, but also will serve as interceptor drains to collect the rising water table. Moreover, the storm water in the dhoros can be utilized by the farmers at the tails of deficit irrigation channels by lifting with pumps. In addition, there is an urgent need to construct new surface drains linked to these dhoros in the left over areas (LOAs), serving agricultural lands that are presently outside the catchment area of the LBOD system. During the extreme rainfall events the people in the LOAs having no outlet drain out the storm water causing unauthorized breachings and flooding particularly in the tail reaches.

Extreme rainfall events of 2003, 2006 and 2011 in the lower Sindh and 2012 in the upper (northern) Sindh caused unparalleled loss to the human lives, marooning of settlements, standing crops, livestock, damage to the physical and productive infrastructure, means of communications, displacement of flood affected population and their livelihoods. These calamities challenged the ability of government agencies to cope with such a catastrophe, and highlighted the need for corrective and mitigation measures to avert similar flood and natural disasters in the future. This experience also provided an opportunity to evaluate the performance of the drainage network, to identify works to strengthen it, and to explore ways to offload pressure on the drainage system. This also flagged the need to identify ways to evacuate storm water from the left over areas presently not served by and connected to any drainage network.

The natural flow of storm water through the dhoros is blocked by low capacity culverts and bridges on the roads, and illegal barriers, settlements, and crops. Consequently, relief cuts were made at numerous places to the banks of natural drains to evacuate flood

waters. Extensive damage is reported to cash crops, orchards, houses and road networks due to flooding caused by the encroachments on the alignment of dhoros and blockage of storm water in the towns. The irrigation water of escapes and breaches of the canal network combined with the storm water played havoc with the neighboring towns and villages and damaged infrastructure in the area. The existing drainage networks of LBOD and Badin designed for lower runoff according to the rainfall conditions at the time of their planning are unable to drain out their catchment areas during high rainfall and other climatic events. To address these issues, the Consultants evaluated the possibility of clearing and reviving the major dhoros to ensure safe disposal of flood waters.

To mitigate the situation, revival of the natural waterways is critical. The natural waterways which used to provide storm water drainage in Sindh are blocked by inadequate or no crossing structures for roads, railways, irrigation canals and even surface drains. Most of the shorter reaches on all dhoros are filled up and are being utilized for crop cultivation. Also fish ponds have been established in dhoros. However, GoS has recently enacted legislation in this regard, and it needs to be enforced and complied with. It appears that after the unprecedented rainfall events of 2011 and 2012 there is strong political will to activate the natural waterways or dhoros to drain out storm water.

ii) Project Location

The project covers about 9.8million acres of cultivable commanded area (CCA) of Ghotki, Sukkur, and Kotri barrages on the left side of the Indus River, including the natural waterways and the areas that are presently not connected to any drainage network. The project area will also include the coastal belt and parts of the Thar Desert where potential depressions are located.

iii) Objectives

The major objective is to improve the drainage of storm water from the left bank area of the Indus River by reviving the natural waterways and constructing new surface / storm drains in the left over areas.

iv) Performance Targets

Revival of Dhoros

- Activation of a part of dhoroPuran, Hiral escape/Pithorodhoro, Hakro dhoro and Naro (Nabisar) dhoro on the left side of LBOD's spinal drain.
- Activation of the second section of dhoro Puran, Sohni dhoro, Bhai Khan dhoro, Sarfaraz (Digri) dhoro, Pangrio dhoro, and Khairpur Gumbo and Roshanabad dhoros on the right side of the spinal drain and MMD including their syphons.
- Activation of Central Sindh dhoros, Khairpur south dhoros and Ghotki dhoros.
- Construction of dhora bypasses for MirpurKhas, Dighri, Jhuddo, Tando Ghulam Ali and Naukot towns if required.

Storm Water Drains in Leftover Areas

- After activation of dhoros to their designed sections as proposed herein or simultaneously with dhoros, **c**onstruction of surface drains in T.Adam, T.Allahyar, T.M Khan , T.G. Ali, Dighri, Umerkot, Farash, Khipro, Khairpur south and Ghotki areas will be conducted.

LBOD Escapes

- Construction of 3 escapes on LBOD including side weirs and link channels to offload 1,000 cusecs through each escape to dhoros.

The outputs mentioned above include the emergency works, including channelization of the dhoros, provision of bypasses where urgently needed, clearance of encroachments and land acquisition, and strengthening existing structures where required. The emergency works have already been commissioned and completed.
The overall impact would be an improved drainage network with sustainable irrigated agriculture and improvements in hygienic conditions in the health sector. By growing high value food crops, the economic status of the rural population can be improved and there would be increased opportunities for employment as new industries develop in prosperous areas. Some of the positive impacts include i) quick evacuation of storm water from crops and settlements, ii) reduced flood pressure on the existing drainage networks of LBOD and Badin by offloading storm water from LBOD at three locations before reaching the Badin area, iii) increased agricultural production through improved crop yields and cropping intensities, iv) reduced losses to infrastructure by diverting the major quantity of storm water to natural dhoros, v) improved environmental conditions in the area, vi) reduced loss to property, human lives, crops, livestock, poultry and fish farms, vii) reduced submergence of structures and back flow in sub and branch drains, viii) reduced water table by drainage flows in dhoros, ix) increased drainage to five leftover areas on the left bank of the Indus, x) enhanced protection to urban settlements with bypasses where critical, and xi) storage of flood water in natural depressions.

v) Cost Estimates

The estimated base cost for the revival of natural waterways is about Rs.35,754

Million ($357.5 million), and of the proposed storm water drainage networks in leftover areas is Rs. 25,310 million ($253.1 million).

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vi) Implementation Arrangements

In view of urgency due to unexpected heavy rainfall during last two consecutive monsoons of 2011 and 2012 in Sindh, the overall time period for this intervention has been restricted to 6 years. The project works are to be executed through competitive bidding by inviting international and national construction firms ensuring full transparency. The construction works are to be supervised for both quality and quantity through renowned international and national consultants in accordance with the proposed designs providing necessary adjustments as needed. It is imperative to monitor the performance of drainage system in the leftover areas on a continuous basis by installing staff gauges at control points. Permanent gauges shall be installed and observed regularly at the outfall point of each dhoro and at Shakoor dhand in addition to the outfalls of drains into dhoros. The depth to water table throughout the left bank area should be observed before and after each crop season.

As the storm water coming into the dhoros is to be utilized for agriculture in the deficit tail reaches of irrigation channels, it should be pollution free. A number of sugar mills and other industries are operating in the command area of drainage networks and are adding highly toxic effluent into drains. They should ensure at source treatment of industrial effluent before it is discharged into the drainage network. In addition, environmental monitoring will be required during construction and maintenance phases

of the project on a regular basis by SIDA. The O&M of the drainage infrastructure and dhoros should also be monitored for discharge capacity and structural safety.

The full benefits of the drainage networks can only be achieved if the proper management of the system is implemented. The drainage benefits may decrease gradually due to poor O&M. Canal supplies must be stopped as early as possible to ensure proper drainage in the event of an extreme rainfall event. Gauge readings at major control points in the drainage networks of the leftover areas, dhoros, and the spinal drain should be monitored on an hourly basis to adopt precautionary measures in time. Vigilant patrolling of the drains and dhoros must be carried out to stop unauthorized relief cuts by farmers and to identify the vulnerable points if any. Relief cuts given by farmers create hindrance in the movement of machinery and maintenance staff in the event of an emergency. All the required machinery should be repaired and mobilized to vulnerable points of the system to meet an emergency. Before releasing the base flow into the drainage system after passing the storm water, the banks and structures on drains and dhoros should be inspected for rain damages and cuts and all urgent remedial repair works should be completed. Reliable and timely information about extreme rainfall events must be provided by Meteorological Department to relevant agencies to avoid losses to standing crops due to longer periods of canal closure. Budget provision for storm emergencies should always be made in the annual plans and re-appropriated for development works if no extreme rainfall event occurs by 30 September every year.

To help overcome the problem of excess water flows in LBOD during high rainfall events, three side weirs are proposed at RD 578, RD 336 and RD 212 of the spinal drain to offload storm water coming from S.Benazirabad, Sanghar and MirpurKhas districts. About 1,000 cusecs will be offloaded at each escape weir and will be sent through link channels to nearby dhoros. Similarly, storm water coming from the proposed new surface drainage systems in the leftover areas will be drained out through natural waterways. Moreover, it is proposed that MMD presently out falling into Puran dhoro at RD 29 should be separated from Puran dhoro to outfall directly into the spinal drain at RD 295 to send its polluted effluent into the sea. The Puran dhoro which was cut off from its natural route will be allowed to underpass the spinal drain through a siphon and follow its original path to Shakoor Lake. By this arrangement about 2,800 cusecs of storm water will be offloaded from the spinal drain. After offloading 5,000-6,000 cusecs of storm water from the spinal drain through escapes and dhoro Puran, it is expected that the submergence of structures and back flows in drains will be greatly reduced.

vii) Economic Return

As the area that will benefit from the rehabilitation of the LBOD, activation of the dhoras, and construction of storm water drainage overlaps and complement, it is cumbersome to isolate the individual contribution to the overall benefits. Hence the economic analysis presented here represents the rate of return to the combined investment in the three subcomponents.

The economic analysis, presented in the table below, shows that the EIRR is about 16.9% and would yield an estimated NPV@12% of Rs.25.5 billion. The sensitivity analysis shows that the investment is quite resilient to decrease in the benefits and or increase in the costs. Similarly, the sensitivity index suggests that the investment is robust.

Table 6: IERR and Sensitivity Analysis of LBOD and Rehab of Natural Waterways

No.	Scenario	NPV @12%	IERR	Switching Value	Sensitivity Index
1	Base Case	25.5	16.9%		
2	Decrease in Benefits (10%)		15.5%	33.0%	2.9
3	Increase in Costs (10%)		15.7%	49.0%	2.6
4	Simultaneous Change by 10%		14.3%	19.5%	2.7

viii) Safeguards

Environmental and social impacts have been studied by the Consultants in detail by conducting interviews with the farming community and other people living in the project area. The drainage system existing in the area is fairly sustainable and with the anticipated improvements at outfall conditions and with increased capacity of drainage network will have major positive impacts and no major adverse environmental impacts are anticipated with respect to habitats and cultural heritage. The proper storm water disposal would protect the cropped area and minimize damages to standing crops. The storm water drained by dhoro Puran and the storm water conveyed by DPOD will carry only unpolluted water. The revival works consist of reshaping and widening the natural water ways, providing embankments with 4 ft free board, and constructing bridges, aqueducts and inlets.

The likely direct negative impacts on the environment include i) construction camps with workers' living and eating areas, mechanical workshops, equipment parking, and construction materials storage and stockpiling; ii) the transport, handling and storage of petroleum products; iii) site preparation, clearing of vegetation, temporary rerouting of traffic, topsoil stripping, and diversion or re-channeling of waterways; iv) removal and placement of earth, and construction machinery moving around the work sites; v) quarries and borrow sites that will borrow earth and aggregates for the fabrication of concrete; vi) air quality and noise impacts during construction; and vii) waste materials from dhoro and drain clearing, concrete making, and other activities that will require adequate disposal sites.

ix) Land Acquisition and Resettlement

A summary and detail of land acquisition and resettlement plan has been prepared for the proposed Natural Waterways and Storm Drains Project and are presented in Appendix 22. No adverse impacts are anticipated, as the GoS has assured that the livelihoods of local inhabitants will be safeguarded.

3 Projects: Improved Environment and Ecology

a. Mangrove Plantation in Coastal Areas

i) Description and Rationale

The length of the Sindh coastline from Karachi to Sir Creek is about 250 km. The total area of the Indus delta is about 600,000 ha and contains 17 major creeks, numerous minor creeks and extensive mud flats. An area of 344,845 ha has been declared as protected forest and an area of 64,378 ha has been transferred to the Port Qasim Authority, leaving an area of 280,467 ha under the Sindh Forest Department (SFD). The Indus delta mangrove ecosystem is of great economic and ecological significance. It provides habitat for a diverse community of organisms ranging from bacteria and fungi

to fish, shrimps, birds, and mammals; provides livelihood to the coastal population; is a major source of fuel wood for coastal communities; provides fodder for camels and buffaloes; protects the coastline from wind and tidal action; reduces siltation of sea ports; reduces the strength of storm surges; and provides eco-tourism.

With the financial support from the governments of Pakistan and Sindh, international donors (including the World Bank and the Asian Development Bank, ADB), and international NGOs (IUCN and WWF) mangrove planting and management have been implemented from the late 1980s and are still continuing. SFD and IUCN, in collaboration with the UNDP/UNESCO Regional Mangrove Project, initiated a mangrove rehabilitation program in 1985 and 3,000 ha were re-planted and some innovative planting techniques were developed.

Under an umbrella project called the Pakistan Environmental Protection and Research Conservation Project, funded by the World Bank, a component called the Rehabilitation and Re-planting of Indus Delta Mangroves, costing about Rs.83.1 million was implemented during 1993-1999. The targets included mangrove planting of 9,100 ha, natural regeneration on 8,000 ha, and a mangrove nursery to produce 1.25 million plants. A follow on 5-year project funded by the Sindh and Pakistan governments was implemented during 2002-2007 and an area of 16,000 ha was planted with mangroves in the coastal area.

With financial support of ADB, the Sindh Coastal Community Development Project was implemented during 2007-2013 including the planting of 10,000 ha mangrove by SFD and the additional planting of 350 ha using a participatory approach with the local people in collaboration with IUCN and coastal community organizations. This was the first time that IUCN and local communities were involved in mangrove planting and management. Using a similar approach, the Conservation and Management of Indus Delta Mangroves for Sustainable Livelihood of Coastal Communities by Reducing Sea Intrusion Project, with Rs.681.55 million funded by GoS is currently under implementation with a target of 36,000 ha mangrove planting, 300 km of mangrove shelterbelts near tidal fringes, the involvement of 50 coastal village communities, and the establishment of mangrove nurseries raising 6 million seedlings. In addition, the Conservation, Management and Community Livelihood Project – Possible Role of Mangroves in Curbing Sea Intrusion in Indus Delta is being implemented since 2010 by IUCN at a cost of Rs.400 million, with a target of 50,000 ha planted. All these projects have been initiated along the coastal belt on both the left and right banks of the Indus River.

This project was identified as a priority by stakeholders from the numerous consultative workshops held during phases I, II and III of the study at the community, district, regional, and national levels. Thatta and Badin are the two major hazard-prone districts of Sindh. Cyclones, heavy rainfall, droughts and floods follow each other often in quick succession. Major disasters in recent years include the cyclones in 1964/65, heavy rainfall in 1973, floods during in 1988, torrential rainfall in 1994, a cyclone in 1999, an earthquake in 2001, severe floods in 2003, severe floods in 2010, and a major flood from rainfall in 2011. It has been established that the resources of coastal areas, particularly the mangroves, fisheries, and agriculture on which the local people are dependent for their livelihoods have been adversely affected. Mangroves almost vanished during the 1999 cyclone, freshwater fisheries have declined due to sea intrusion in the existing dhands thereby converting freshwater areas to brackish water areas, and the agricultural area has been adversely affected by poor drainage and sea intrusion.

ii) Project Location

The project will be located in coastal area of Badin and Thatta districts, comprising the coastal talukas (sub-districts) of Badin and S.F Rahu of Badin district and Jati and Shah Bander talukas of Thatta district.

iii) Objectives

The objective of the proposed Protective Plantation of Mangroves in the Coastal Areas of Left Bank Project is to provide protection to the coastline and the delta ecosystems ensuring sustainable livelihoods to the local communities. The project will create a biological screen or shelterbelt to protect the lower reaches of the drainage system and the coastal area from erosion and sea water intrusion. In addition, the proposed intervention will support fish production, provide fuel wood and fodder to local communities, and improve their livelihoods. The establishment of mangrove forests is also in line with the clean development mechanisms (CDM) and will act as carbon sink.

iv) Performance Targets

The main outputs of the proposed interventions are: i) container plant nurseries to produce 15 million seedlings, ii) mangrove plantation on mudflats in the frontage of sea and backwater (35,000 ha), iii) plantation of mangrove belts along the wetlands and tidal link and around the perimeters of the wetlands and dhands (15,000 ha), iv) plantation of salt tolerant species in the supra tidal zone (12,000 ha), and v) community mangrove planting (8,000 ha) in the coastal area. The total plantation target is 70,000 ha. *Avicennia marina, Rhizophora mucronata* and other species of mangroves will be planted.

The main impact of the proposed project will be:

i) reduction in coastal erosion and seawater intrusion and backwash, and further degradation of fertile land
ii) enhanced fish production in the wetlands and dhands
iii) reduction in damages from cyclones and other climatic events
iv) reclamation of productive lands in the coastal area
v) secured livelihood for the local communities
vi) improved environment and ecology

v) Cost Estimates

The total base cost of the project is about Rs.1,319 million ($13.3 million). The cost estimate is based on the existing unit rates used in the development projects. The implementation period for the proposed project is 7 years.

Efforts will be made to solicit bilateral and multilateral funding support from the development partners. Mangrove development initiatives are CDM-type projects which are usually funded from allocations made to member countries of international protocols such as Kyoto Protocol, MFF, UNFCC, REDD and REDD+. Pakistan is a signatory on all these UN protocols. The Pakistan Government, GoS, international donors, and NGOs will also be requested to join to fund and implement this project.

vi) Implementation Arrangements

The proposed project will be implemented through participatory approach by involving all stakeholders from project preparation, execution, and benefit sharing. Using the participatory approach, the local communities will be involved from the initial stages of

project development, survey, selection of sites, planting, maintenance, protection, and distribution of benefits.

vii) Economic Return

The EIRR for the project is about 17.9%. The NPV at 12% is Rs.601.2million. The sensitivity analysis presented (switching values) in Table 5 shows that that if the benefits decrease by about 47.5%, or the costs increase by more than 50%, or even if both change simultaneously by 31.0%, the project will still be viable (above the threshold of 12%). The sensitivity index suggests that the investment is quite robust.

Table 7: IERR and Sensitivity Analysis of Mangrove Plantation

No.	Scenario	NPV @12%	IERR	Switching Value	Sensitivity Index
1	Base Case	601.2	17.9%		
2	Decrease in Benefits (10%)		16.8%	47.5%	1.8
3	Increase in Costs (10%)		16.9%	88.2%	1.6
4	Simultaneous Change by 10%		15.9%	31.0%	1.7

viii) Safeguards

Mangrove forests provide environmental services in many ways. They i) protect the shoreline from storm surges, cyclones and other extreme weather events, ii) trap pollutants and reduce the effects of flooding, iii) check sea intrusion and reduce its adverse impacts, iv) protect structures (tidal link, bunds etc.), v) improve fish habitat in wetlands and mangrove areas, vi) prevent soil erosion, vii) serve as carbon sinks and stores of biodiversity, viii) improve landscape beauty, and ix) provide several ecosystem services. If the project is developed under CDM, it may generate carbon credits which will be owned by the Government that can be used for other CDM projects. Hence, the project has several environmental benefits and is environment friendly.

The proposed project will have positive impacts on the social aspects of the society such as poverty reduction, income distribution, employment generation, livelihood opportunities and gender mainstreaming. With the development of this project and its implementation through integrated and participatory approaches the coastal people will be mobilized, organized and act as implementers and managers, and they will get direct and indirect employment and sources of livelihood which will ultimately alleviate poverty and distribute benefits equitably. Furthermore, the communities will own the project. Women will also be involved in all the processes of the project. No resettlement will take place as the project will be implemented on government forest land.

b. Forest Plantation Using Drainage Water (Pilot)

i) Description and Rationale

Agro-forestry on farmlands is an important land use of Sindh. Analysis of the forests during the process of consultation in phase I and literature review revealed that these forests and farmland plantations have been degraded due to a variety of social, economic and environmental problems. The major causes of tree resource degradation include:

i) deforestation/overcutting and depletion of trees from forests and farmlands

ii) decline in the productivity and composition of forests and farmlands

iii) shortage of tree resource and associated services

iv) lack of participatory approaches and poor project coordination

v) decline in per ha vegetation cover

A common problem for establishing new forests, maintenance of existing ones, and farm plantations is the scarcity of irrigation water from river, canals, distributaries and water courses due to overall shortage of water in the systems. However, the quality of drainage water in the project area is good enough for use in tree plantations by diverting it from nearby drains to nearby forests and farmlands. Research carried out indicates that drainage water is useful for tree species. SFD has been promoting development of tree resources both on forest and private lands through its development projects and social forestry program. SFD has two wings: the territorial wing for the management of various types of forests, and the social forestry wing for the promotion of forestry on private farmlands, nurseries, and extension services.

One of the options is to use drainage water in a conjunctive or cyclic way with canal water. Accordingly, a pre-feasibility titled "conjunctive/cyclical use of drainage water for forestation on government forest lands and private farmlands in LBOD and Kotri surface drainage command area" was prepared during the phase II of the study and discussed with the stakeholders at the village, district and regional levels. The drainage water will either be mixed with available irrigation water or used in a cyclical form by supplying canal water for a certain number of irrigations and then supplying drainage water of acceptable quality for other irrigations. Based on the technical evaluation and stakeholders' inputs during phase II, a feasibility project was prepared and discussed with the stakeholders in workshops, meetings, and field visits during phase III.

ii) Project Location

The proposed project is located in two areas: i) the LBOD command area located in Shaheed Benazirabad, Sanghar and Mirpurkhas districts, and ii) the Kotri surface drainage system located in Thatta and Badin districts.

iii) Objectives

The scope of the proposed project is to improve the vegetative cover on both forest land owned by the government and private farmlands by supplementing drainage water of LBOD and Kotri drainage areas with canal irrigation water. The objectives of the project are to i) combat deforestation through tree plantation, ii) explore alternate uses of drainage and storm water for growing forests, iii) improve the productivity of degraded lands, iv) improve the quality of tree resources on government forest land and private farmlands, v) overcome irrigation water shortages with conjunctive use of drainage water, vi) enhance green infrastructure to promote biological drainage, and vii) improve the environment through carbon sequestration

iv) Performance Targets

Raising of nurseries of salt resistant seedlings for forestation	15 million seedlings
Plantations on government forest land	6,000 ha
Plantations on farmlands through social forestry	4,000 ha

v) Cost Estimates

The total base cost of the project is estimated as Rs.304.0 million ($3.0 million).

vi) Implementation Arrangements

The project will be executed by SFD over a period of 5 years. A participatory approach will be adopted. SFD, Sindh Irrigation Department, SIDA, private farmers, and local civil society organizations and communities are the major stakeholders for this intervention. All will be involved in the planning, implementation, O&M, monitoring and evaluation. The project will use the social and agro-forestry approaches and methodologies for implementation.

Site selection will be conducted in consultation with the stakeholders and the broad criteria to be used will include i) the area to be planted should be located close to drainage system; ii) it should be located close to an irrigation channel and should have a water share from that water channel; iii) in order to utilize water from both the sources in a conjunctive or cyclic form, the concerned stakeholder should show his/her willingness to afforest that area; iv) the area should be degraded but not completely waterlogged; v) it will be better to afforest the areas where there are clusters of participating farmlands and the farmers jointly show their willingness to use drainage water and irrigation water allocated for that land; vi) the farmers are willing to formulate a CO (optional) to execute the proposed intervention, decide roles and responsibilities, and other aspects of intervention; vii) the CO should be willing to spend some money for excavation of water courses separately for drainage and irrigation water and take responsibility for their O&M; viii) the project will only pay for supply of drainage water at source through construction of an outlet and if required lift machines to release drainage water from drains; ix) the initial land development and planting costs will be borne by the project but restocking, irrigation within the farm(s), and O&M will be the responsibility of individual farmers; x) technical assistance and extension services will be provided by the concerned wings of SFD, the Irrigation Department, and SIDA; and xi) for planting on government forest land almost the same criteria for site selection will be observed except that SFD will be the sole owner of the area to be afforested and areas closer to drainage systems will be identified.

The tree species proposed for the project include *Acacia nilotica, Albizzia lebbek, Casuarina equisitifolia, Eucalyptus camaldulensis, Leucaena leucocephala, Parkinsonia aculeate, Prosopis cineraria, Prosopis juliflora, Sesbania bispinosa, Sesbinia sesban, and Tamarix aphylla.* All are saline water tolerant and will grow successfully.

vii) Economic Return

The proposed methods of irrigation will best utilize the drainage effluent for forestation and also meet the shortage of irrigation water from canals. Above all, the environment of the area will improve and the degraded and unproductive lands will be brought back to productive uses which will ultimately increase tree resources, combat deforestation, improve livelihoods, and alleviate poverty.

The EIRR for the project is about 24.0%. The NPV at 12% is Rs.253.6 million. The sensitivity analysis presented (switching values) in Table 5 shows that that if the benefits decrease by 57.3%, or the costs increase by more than 50%, or even if both change simultaneously by 39.9%, the project will still be viable (above the threshold of 12%). A very low sensitivity index suggests that the investment is quite stable in trems of changes in the benefits and the cost of investment.

Table 8: IERR and Sensitivity Analysis of Forest Plantation

#	Scenario	NPV @12%	IERR	Switching Value	Sensitivity Index
1	Base Case	253.6	24.0%		
2	Decrease in Benefits (10%)		22.3%	57.3%	1.4
3	Increase in Costs (10%)		22.5%	134.0%	1.3
4	Simultaneous Change by 10%		20.8%	39.9%	1.3

viii) Safeguards

The proposed project is environmentally friendly on the grounds that it will not have any adverse impacts on any green infrastructure of the areas, will utilize the drainage water for growing trees and shrubs, will improve degraded lands and increase their productivity, and will improve the physical and chemical structures of the degraded soils through biological drainage and nitrogen fixation.

The proposed project will have several socio-economic benefits for the society including i) enhanced productivity of lands in the form of food, wood, fodder, and fuel; ii) increased livelihood opportunities for farmers and associated employed workers; iii) increased incomes and local economic growth by improving the productive capacity of degraded and unproductive lands; iv) improved grazing areas and habitats for livestock and wildlife; v) improved agricultural and livestock outputs that will improve the socio-economic conditions of the farming community and associated stakeholders; and vi) enhanced knowledge of the use of drainage and sweet water in conjunctive and cyclic forms as the technology is transferred from the scientific community to farmers. The project will not require any resettlement.

c. Rehabilitation of Deh Akro II and Chotiari Wetlands

i) Background and Rationale

Wetlands are the storehouses of globally endangered biodiversity of flora and fauna because of their extensive and rich food webs and biodiversity. They are also an important source of livelihood for the wetland dependent and typically poor communities. The wetlands are ecosystems that provide goods and services that have economic values for both local populations and downstream beneficiaries. Furthermore, wetlands also provide recreational opportunities and amenities, flood control and storm buffering, and a range of ecosystem services, including ground water recharge, water purification and eco-tourism.

There are 19 wetlands declared as Ramsar sites in Pakistan, of which 9 are located in Sindh and 6 are situated on the left bank of the Indus: Deh Akro, Nurruri lagoon, Jubbo lagoon, Runn of Kutch, Indus delta, and the Indus Dolphin Reserve. They have gained importance due to their unique biodiversity and habitat which shelters large number of species. The total area of wetlands as reported by SWD is 5000 ha. There are three important wetland complexes located on the left bank of the Indus in Sindh, namely Deh Akro II, the coastal wetlands and Chotiari reservoir and wetlands located in Shaheed Benazirabad, Badin and Sanghar districts, respectively.

Deh Akro II is wildlife sanctuary and was declared as a Ramsar site under the UN Convention on Wetlands. It consists of four major habitats: desert, wetlands, marsh and agriculture. It is a natural inland wetland ecosystem, which supports a variety of rare and endangered wildlife species. This area hosts a considerable number of rare fauna. Many

indigenous fish species are also found. Water scarcity during a persistent dry spell is adversely affecting the area. There are 36 wetlands forming a complex and having pre-dominant wildlife species of crocodiles. This area is managed by the Sindh Wildlife Department (SWD).

The Chotiari wetlands extend over 20,000 ha and include about 36 lakes, of which 5 are freshwater and 31 brackish water, fed by seepage from the Chotiari reservoir supplied by the Nara canal and its Jamrao branch. The reservoir is actually part of the Chotiari wetlands and is the largest of the lakes that feeds the other 35 lakes to the northwest. Located in a typical stable sand desert habitat, the lakes occupy flat bottomed valleys surrounded by 5-10 m high sand dunes. The reservoir is used to store water and then release it into the canal when downstream farmers are short of water. The stored water in the reservoir is usually drained completely during these times. Seepage from the reservoir also causes water logging to adjacent farmland in the south and west. This reservoir is managed by the Irrigation Department and SIDA and the wildlife by SWD.

These wetlands are under threat due to lack of awareness of its economic importance and poor management. The stakeholders during the consultative workshops reported that in both wetlands the major issue is the shortage of water required for the survival and growth of the wildlife species. Most wetlands are water stressed causing serious threat to the wildlife species available in these wetlands.

Ideally, the original water allocation for wetlands needs to be restored in order to avoid further degradation. The stakeholders suggest that water be supplied to head lakes in Deh Akro II through a parabolic watercourse off taking from the Jamrao Canal, operating during the peak flow months. In addition to this, the stakeholders suggested dredging of silted lakes whose storage capacity has been reduced over time. Other issues include indiscriminate hunting and poaching.

In Chotiari, some water should always be retained in the reservoir to supply water to other linked lakes. Many stakeholders expressed that water logging from reservoir seepage is a serious threat to their livelihoods. The stakeholders concurred with the proposed solution of dig moats or ditches along the western and southern embankments of the reservoir. These moats would intercept seepage water before these can reach farmland areas. Also proposed was a grid of surface drains from the fields to the moats. A few participants of the workshops also suggested that there is an urgent need for the Wildlife Department to be strengthened for effective wildlife management. Details are in Appendix 12.

ii) Project Location

The Deh Akro II wetlands are located in the desert area of district Benazirabad and about 30 km east of Nawabshah City. The Chotiari reservoir and wetlands are located in District Sanghar and about 20 km east of Sanghar City.

iii) Objectives

The objectives of the proposed project are a) provide a minimum quantity of water (2 meter depth) to both wetland complexes to keep them productive, b) to check seepage from the Chotiari reservoir and improve drainage to reduce water logging and increase farm productivity, and c) provide improved protection to and management of the rich biodiversity in these wetland complexes.

iv) Performance Targets

Ideally, the original water supply should be restored in order to avoid the environmental and economic negative effects of lakes drying out. In reality, this will probably be impossible. What could be possible however would be to provide the wetlands with sufficient water to prevent the lakes from completely drying out and allow them to sustain life on a year-round basis. Both structural and non-structural measures are suggested. Structural measures include the construction of watercourse linking the Jamrao canal to the head lake(s) of Deh Akro II. The watercourse will carry 2 cusec of water from the canal. This watercourse would be about 4 km long, and its diameter about 2 feet wide to allow a strong flow to pass through. The connection between the canal and watercourse would only allow flows during the peak flow time in the Jamrao canal. Diverting some water only during peak flow periods should avoid creating water shortages downstream. Also, having only high speed flows in the watercourse should allow it to remain free of silt deposits. In order to regulate the water from Jamrao canal a flap gate is proposed. Non-structural measures include excavating and deepening the shallowest lakes to restore their storage capacity and resilience to droughts. This will depend on local ecology and of dune stability in the immediate surroundings of the concerned lakes.

For the Chotiari wetlands, two options are suggested with two different structural measures, depending on the depth reached by underground seepage water. A complementary non-structural measure is also presented to improve the efficiency of the structural measures. The buffer zone between the reservoir bund and the new Nara canal will be planted with trees so as to act as biological drainage. The first structural measure would consist in digging one surface drain along the southern embankment of the reservoir. The drain would intercept seepage water before it can reach farmland areas and drain off into the Nara canal using 8 lift pumps. The alternative structural measure would be to create a grid of 15 shallow drains that would prevent the topsoil from becoming waterlogged or flooded. It is also proposed that 10 tubewells be installed to drain water through a vertical drainage system.

v) Cost Estimates

The total base cost of the proposed project is about Rs.392.8 million ($4 million).

vi) Implementation Arrangements

The Deh Akro II wildlife sanctuary is presently being managed by SWD. The proposed project will also be implemented through this department and the local communities residing around the Deh Akro II Wildlife Complex. The Chotiari reservoir is being managed by SIDA and the wetlands by SWD. The drainage activities proposed will be implemented by SIDA.

The project also proposes the use of consultants (an ecologist and a social specialist) to prepare a wetlands and wildlife management strategy and management plan for each wetland area of Sindh including Deh Akro II, Chotiari, and the coastal wetlands and lakes (dhands). The management plan will address the sustainable use and development of the resources of wetland areas so as to improve quality of life, maintain biological diversity, and sustain the productivity and quality of the wetlands through efficient and integrated management. The management plan should propose action plans for three of the main wetland complexes.

vii) Economic Return

As the main benefit is the improvement of the environment, including the wildlife and the waterlogged area near the Chotiari reservoir, an economic evaluation was not conducted.

viii) Safeguards

The proposed intervention is environment friendly as it will not create any environmental problems but will improve the existing environmental problem of water logging in the area and provide water for wildlife. The activities in the Deh Akro II will help address the problem of water scarcity and reduce the impact of drought in a complex of 32 wetlands. This site has rare species of crocodiles and fish and other wildlife which will benefit from the project interventions. The main problems needing immediate assistance in the Chotiari reservoir and wetlands is improving water supply to the wetland lakes and reducing the water logging in the adjoining fields through seepage from the reservoir. By maintaining some water in the reservoir, water will continue to seep into the adjoining wetlands. By addressing the water logging, the affected agricultural lands will be more productive. It is thus concluded that the proposed project of rehabilitation of Deh Akro II and Chotiari wetlands is environment friendly and also socially acceptable with no negative impacts. There will be no land acquisition or resettlement**.**

D REGIONAL PLAN BENEFITS AND ANALYSES

1 Benefits and Impacts

It is anticipated that the improved drainage system will facilitate the evacuation of the drainage effluent and storm water flows and will reduce losses to human lives (and injuries and water borne diseases), and damage to standing crops, stored grains, livestock, fisheries, and physical and social infrastructure. The improved drainage system will also enable the planting of crops in the low lying areas where cultivation was constrained due to ponding of the storm water. The timely evacuation of water will mitigate backwater flows, arrest seawater intrusion, and restore the productivity of degraded lands and water bodies, and facilitate improved rural and coastal livelihoods. The farms and rural inhabitants in the left over areas not currently linked to the dhoros will also be major beneficiaries.

The plan will provide drainage and reduce flood damages to about 5.5 million acres in 14 districts, from the current 1.7 million acres in the four districts currently served by LBOD. It will provide protection from flood damage to a population of about 21 million from about 6.3 million persons that are currently served by LBOD. With the rehabilitation of LBOD and extension of drainage system in the areas that presently do not have access to any drainage facilities, the evacuation time of the storm water will be reduced from three months in a normal flood year to about two to three weeks. The drainage system and timely evacuation will ensure minimum disruption to access to social services (particularly health and education), availability of fodder for animals, incidence of water borne diseases, and, uninterrupted livelihood activities. It will also revive the fish production in the water bodies, and create overall economic synergies.

The projects on mangroves, forest plantations using drainage water, and wetlands will also benefit both the environment and local inhabitants that are dependent on these natural resources. Use of participatory approaches in project design, implementation, and monitoring will help ensure that local people will benefit from the interventions.

2 Financial and Economic Analyses

The economic viability of the core interventions is presented below, with associated estimated NPVs at 12%, switching values and sensitivity index. The main benefits of the drainage system intervention would accrue from the averted flood water damages. Details are in Appendix 18.

Table 9: EIRR, Net Present Values, and Switching Values

Project	EIRR Base Case	Switching Values			NPV at 12% Rs. million
		Reduced Benefits	Increased Costs	Simultaneous Change	
Rehabilitation of LBOD and Revival of Natural Waterways, and Storm Water Drains	16.9%	33.0%	49.055.6%	19.5%	25,505
Mangroves Plantation in Coastal Areas	17.9%	47.5%	>50%	31.0%	601.2
Forest Plantation using Drainage Water (Pilot)	24.0%	57.3%	>50%	39.9%	253.6

Economic analysis of the Deh Akro II and Chotiari Wetlands Project was not conducted.

The sensitivity indices range between 1.3 and 2.9, suggesting the investment is quite stable and robust, and are not very sensitive to changes in the costs and benefits.

3 Technical Considerations (Hydrology)

The rainfall in the study area is erratic and confined to the monsoon period from July to September. The dominant pattern of the monsoon is two to three medium downpours during July or August. Heavy rainstorms normally occur in August and September. The winter months or Rabi season receives less than 10% of the total rainfall. Some years are very dry while others get plenty of water. Both scenarios cause problems, either drought or flooding because the rains are not evenly distributed during the monsoon season, but fall within few days. Figure 1 presents 34 years of annual rainfall recorded in Badin. More information in this regard is presented in Appendixes 2 and 6.

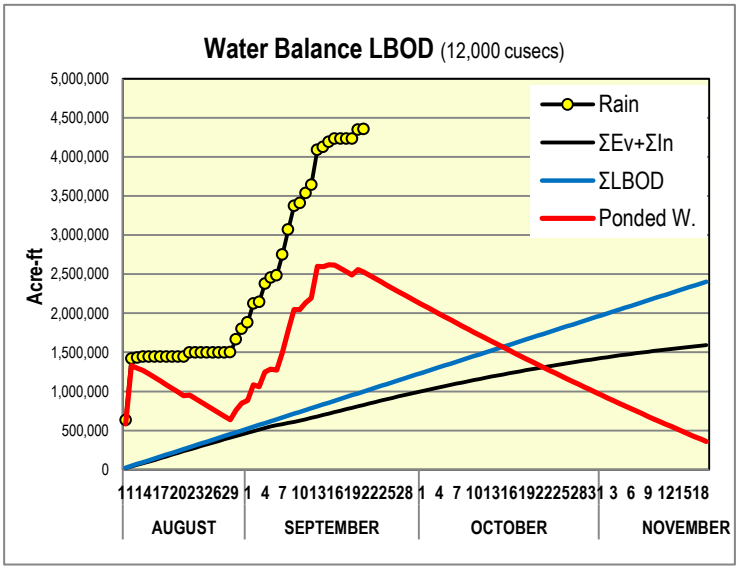

Figure 1: Water balance LBOD (12,000 cusec)

The monsoon season of 2011 experienced remarkably high rainfall, particularly in the left bank of the Indus. The cumulative rainfall varied between 423 mm to 1,143 mm. In Badin District, 615 mm was recorded. The precipitation recorded in Badin on August 11 and 12 was 148 mm and 147 mm, respectively. If each daily event is observed independently, each has a minor return period when compared to the maximum daily precipitation frequency analysis as seen in Figure 2. However, when combined they show a major flood event. The combined rainfall was 297 mm, which corresponds to a much larger return period. The detailed analysis is in Appendix 6. The two days rainfall frequency analysis is presented in Figure 3 which shows that the 297 mm event corresponded to a return period much larger than LBOD's design capacity.

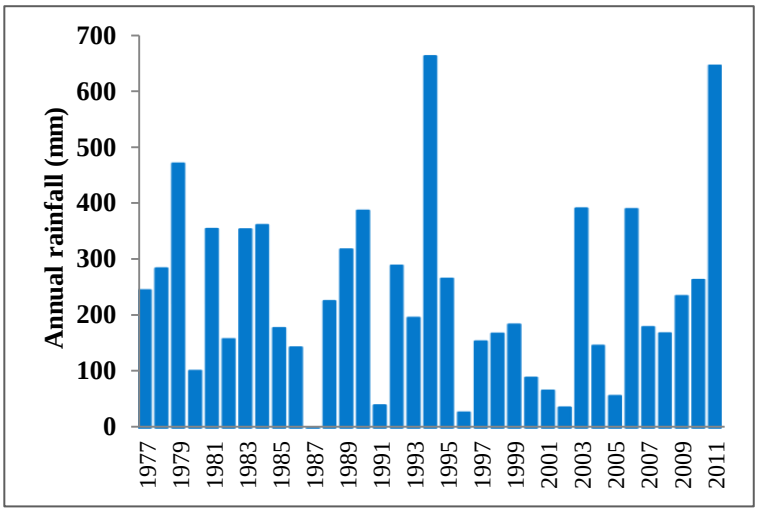

Figure 2: Badin annual rainfall

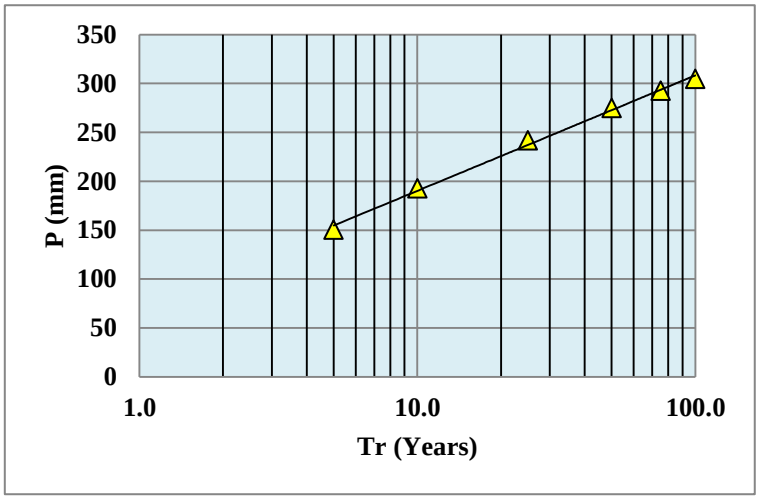

Figure 3: Badin maximum two days rainfall

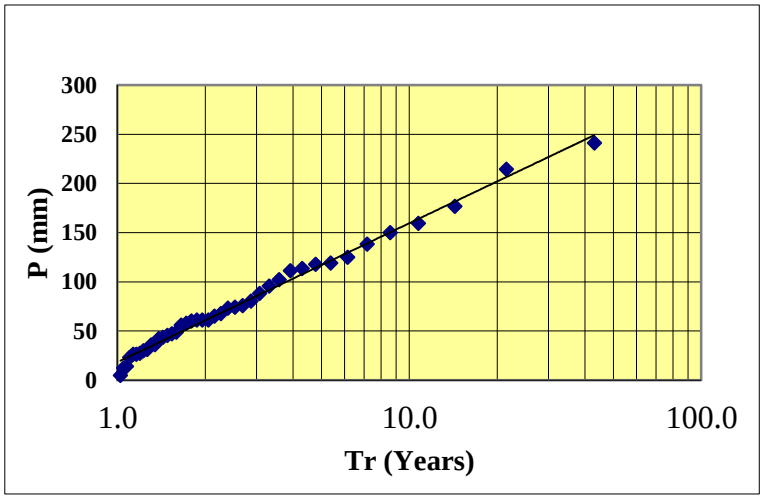

Figure 4: Badin maximum precipitation per day

Badin District did not experience significant rainfall during 2012. However, the precipitation recorded in the northern districts was significant. The rainfall in 2012 mainly occurred during September, rather than in August as was the normal pattern. The rainfall recorded on 10 September of 305 mm was exceptional for Jacobabad with a return period of more than 100 years, and was followed by another rainfall of 143 mm of a near 20 years magnitude the day after. The combined effect of the two storms caused major flooding in the area. Once again, it became evident that the rainfall frequency analysis

should not just be conducted for maximum daily rainfall alone, but for two days and perhaps more.

The rainfall-runoff relationship in the area can be highly complicated. Since the terrain is so flat, it is difficult to clearly identify the catchment areas of the basins and sub-basins. Also, since relatively minor effort is required to change the terrain slope, trans-boundary water beyond the designer's estimates is always possible. Also, as was reported by the World Bank experts in 2005, *"LBOD canals were overtopped and numerous breaches occurred in part because farmers in the upper LBOD basin cut the banks of the drains to hasten the drainage of rain water from their fields."* The Consultants have also observed that some farmers in the upper reaches pump water out of their fields into irrigation canals, which in turn escapes into LBOD.

In September 2011, a water balance model was prepared to predict the time the LBOD system would take to drain the area. The model assumed a capacity to drain about 12,000 cusecs. The daily evaporation was calculated and the infiltration estimated from existing data. The model results showed that ponding was to continue for long time as can be observed in Figure 4, where the red line represents the volume of water ponding in the area. From the model, it can be concluded that it is not possible to evacuate the ponded water within a few days in the event of a similar magnitude event as 2011. The limitations presented by Dhoro Puran and LBOD itself imply that ponding should be expected. Appendix 6 presents a more detailed analysis of the hydrology and the water balance of the area.

4 Environmental Benefits and Impacts

Sindh experiences two types of flooding. High rainfall or snowmelt from the upper regions of the Indus River can result in high levels of water in the river that cannot drain quickly, resulting in flooding at different points in Punjab and Sindh, as was the case during the 2010 flood. It is predictable when it reaches Sindh and allows time to respond. The second type of flooding is caused by high rainfall in Sindh itself. Storm waters get trapped due to lack of proper outlets as was the case during the 2011 and 2012 floods.

Nature created a number of channels to drain storm water on the left bank of Indus River. Manmade blockages and illegal encroachments in the dhoros have created anthropogenic hazards, including urban settlements, infrastructure (such as bridges, culverts, canals, aqueducts, etc.), and agriculture. These obstruct the natural flow of water and create ponding with all the negative environmental effects that accompany unwanted pooling of water and flooding. The RMP proposes to activate and improve the dhoros in an effort to restore the natural storm drainage flow, while ensuring that they will not carry waste and polluted water. The ecosystem of the area will not be adversely affected with these improvements as the dhoros have been in existence for hundreds of years, no chemicals will be utilized, and no flora or fauna will be affected. Details of the environmental assessment and the situation of the dhoros are in Appendixes 9 and 19. The rehabilitation of LBOD will generate limited negative environmental impact during the construction period that needs to be safeguarded.

The coastal area of Sindh is exposed to cyclones and other climatic events. The Sindh coast had an average of four cyclones in a century but probably due to climate change, the frequency and intensity has increased during the last few decades, augmenting the associated risk. Coincidently, the last decades have also experienced considerable decline in mangroves in Sindh. The cyclone experienced in 1999 affected 73 settlements in Badin and Thatta districts striking 73 settlements and caused about 170 deaths.

Natural vegetation has proved to be excellent for protection of riverine areas against erosion and flooding and in a similar way mangroves have proved to be outstanding for protection against climatic events and disasters in the coastal areas. Mangrove forests are very effective wave energy dissipaters. Mangroves are able to dissipate between 70-90% of the energy from normal ocean waves. By analogy, mangrove forests are the "windbreak" trees of the shoreline. The first belt of mangroves absorbs most of the waves' energy with their sturdy branches and interweaved roots. The next row or belt of mangroves tend to grow taller because they are not as exposed to the waves' action and absorb more of the remaining energy until it is dissipated. The RMP proposes to plant mangroves wherever feasible along the coast and parallel to the Tidal Link to help control erosion and stabilize the Tidal Link.

The main issues that have to be addressed during construction phase of the project as included in Appendix 19's environmental management plan include:

i. Safe disposal of silt cleared from LBOD. LBOD silt is contaminated by the polluted water of LBOD's base flow. It has no value and should not be used for improving soil texture, and its proper disposal should be planned.

ii. Cutting of trees and clearance of vegetation would be minimized. Additional trees would be planted close to the dhoros. Tree plantation would be done using appropriate species natural to the areas, that can also provide economic benefits to the people and help in ecological drainage and reducing soil salinity. It is expected that the new trees planted would be at least three times more than the amount cut;

iii. Proper management of borrow pits or excavation areas to avoid hazards;

iv. Proper management of construction sites, control of dust and noise pollution, disposal of hazardous or other unused insert material, management of construction traffic, working hours, and scheduling acceptable to local communities and affected people in the vicinity;

v. Proper construction planning and closing or diverting canals or drains for construction purposes should be consulted with the affected stakeholders during the pre-construction phases and agreements would be reached. These plans should be prepared by the contractors according to their construction schedules.

5 Social, Poverty, Gender, and Employment Benefits and Impacts

Social benefit and impact assessments were conducted throughout the study area. Community consultations were conducted in 91 sample villages in 7 districts (more information is in Appendixes 20 and 21). The following is a summary of stakeholder views:

Perceived positive impacts

- Water will drain out fast
- Water logging and salinity will decrease
- Agriculture production will increase
- Houses and land will be safer
- Livestock will get sufficient drinking water
- Diseases will decrease
- Necessary drainage system will be developed
- Paid local labor opportunities will increase

Perceived negative impacts

- Crops and structures located inside the dhoros will be adversely affected
- Access to other sides will be hard if bridges are not constructed
- Possible damage or cut of bunds would harm local communities
- Improper monitoring, maintenance and management will damage the whole area
- Potential overflowing of drains will damage houses and livestock
- Any backflow will affect the area
- Some people will be relocated

The projects will benefit all sectors of society. Reducing losses due to flooding will benefit those who are more exposed to the floods, but will also have direct effects on the cost of food and goods which affect the society as a whole. Less risk associated with the loss of crops and livestock from flooding will reduce price escalation and repair and construction of bridges, culverts, pathways, etc. will improve communication and transport and reduce costs.

The project will also have a positive impact on health by minimizing the common outbreaks of waterborne contagious diseases during flooding. Flood incidents are expected to decline and the time needed to drain out flood waters will also decline and less water will be ponded. Reductions in waterborne diseases and improved health should benefit all members of society, and there should be less chances of transmitting the diseases. The expected result will be improved quality of life, reduced diseases, and reduction in health expenses.

The poorer population is more at risk and more vulnerable from flooding than those with higher incomes. Both rural and urban poor people tend to reside on land more prone to natural and man-made disasters and their homes are usually made out of mud or low quality materials and are more vulnerable to flood damage. During the 2011 floods about 700,000 mud houses were damaged (of which more than 50% were totally destroyed) and during the 2012 floods about 90,000 mud houses were damaged. About 300 people were reported to have died in both floods. The flood control and drainage projects proposed should have a major positive impact in the number of houses damaged and destroyed by the flooding and human and livestock deaths and injuries. The projects will also create a very large number of jobs that will benefit all sectors of the society during construction and also afterwards in the operation and maintenance activities of the structural and non-structural schemes executed. The non-structural projects will mainly benefit the rural poor by creating sources of income, reducing financial vulnerability, and improving their quality of life.

Women's role in society is mainly concentrated on their reproductive role, the care of children, the elderly and livestock, and household tasks including water collection, cooking, cleaning, washing, etc. Women also do agricultural work especially during peak labor times of planting and harvesting. Land rights are often denied or reduced to women as the tradition limits their inheritance and property rights. Owning limited assets, flooding present a major threat to women's limited wealth. Flooding events often harm women more than men in terms of injuries and death. Women are generally not as strong as men and focus on trying to save their children, the elderly and their assets, and expose their own lives in the process. They tend to place the needs of their family over their own needs. If after the flooding the family finds shelter in a refugee camp, women's domestic

responsibilities continue, as they have to find ways to take care of their family needs in a limited and often difficult environment. The flood control projects will definitely have a positive impact on women's lives by minimizing the risk they take with their own lives, by reducing their suffering in case of flooding, and by protecting their assets.

The projects will create thousands of direct and indirect employment opportunities. Among the direct jobs will be managers, engineers, social scientists, economists, environmentalists, agronomists, accountants and a variety of other professionals, plus skilled and unskilled workers who will be deployed to the various construction activities. The civil works will use heavy machinery and equipment in addition to hundreds of farm tractors (farm tractors can be used by the FOs to excavate the dhoros), and skilled, semi-skilled and unskilled labor. The investment over 6-7 years is expected to create about 750 person-years of professionals, about 48,000 person-years of skilled labor, and 64,000 person-years of unskilled workers.[1] Sindh has shortage of professionals and skilled workers and it is expected that some skilled workers will have to come from other provinces, but the unskilled labor should be from Sindh.

6 Risks and Mitigation Measures

Risk	Mitigation
Investment in rehabilitation of LBOD and activation of the dhoros may not be possible due to the very large investment expenditures required.	The implementation of the RMP needs to be divided into various phases and packages. The packages need to be independent of each other. Priorities should be identified.
Non-structural interventions can fail if the sugar mills' effluent is not treated and if municipal sewage continues to pollute the drainage water.	Commitment from the sugar industry to comply with the environmental law and the authorities to enforce it should be a condition before the implementation of those schemes that are vulnerable to polluted industrial effluent.
Delays in the availability of funds and/or delays in the implementation of the construction activities	
Financial sustainability of SIDA drainage systems due to poor institutional capacity of FOs and AWBs	Financial sustainability depends on the FOs' capacity to collect the tax or cess. This risk can be minimized by providing technical assistance, social assistance and bylaws.
FOs may be unwilling to participate in the maintenance of the minor drains. Local inhabitants are not adequately involved in planning, planting, and management of mangroves to ensure sustainability.	Participatory approaches involving villagers and stakeholders will be emphasized during implementation.

[1] Based on the WSIP-I PC-I, 11,250 annual skilled and 15,000 annual unskilled laborers with an investment of $175,000.

Risk	Mitigation
Capable contractors may not be attracted to bid on the civil works.	The minor drains and dhoros construction and rehabilitation works will be large enough to attract qualified international and national bidders. Some works can be handled by FOs. Farm tractors can be used to shape the dhoros.
Effective drainage will continue to be difficult because of obstructions in drains and illegal cutting of the banks of canal and drains by local inhabitants	Participatory approaches combined with farmers' education about the downstream effects on LBOD and the dhoros should be emphasized during implementation.
Flood and disaster control structures and management planning will be jeopardized if the irrigation canals are not closed during high rainfall events.	Rainfall warnings from the Metrologic Department should be carefully assessed and ID, SIDA and AWBs should be educated about the devastating effects of leaving irrigation canals open during storm events.
Quality control during construction is not kept at a high standard.	Proper supervision must be enforced.
Maintenance in not adequately funded or implemented.	GoS must provide the required funds for proper maintenance. Periodic technical audits by external consultants on maintenance work should be conducted.
Sea water intrusion does not allow mangroves to multiply.	Mangroves will be planted initially where survival rates will be high, and then gradually planted in areas made secure.
The proposed interventions will be owned by SIDA after construction. Consequently, there will be acquisition of private proprietary land on permanent basis.	As compulsory land acquisition is involved, conflicts between the EA, the contractors, and landowners are likely. However, the resettlement action plan and grievance mechanisms will be implemented in a participatory manner.

Risk	Mitigation
Land required for establishing contractor's facilities including camp, workshop, plants, earth material and dumping excess spoil will be temporary acquired directly from private landowners by the contractor.	SIDA and supervisory consultants will monitor the process of restoration and ensure that landowners are compensated according to the terms of the lease agreements, and the restoration actions agreed upon by the contractors are duly carried out. Similarly, prior to the commencement of construction activities, the contractor will carry out baselines survey for selecting the camp sites, dumping sites, public and community/private owned utilities.
Dhoros may be used to convey polluted agriculture, municipal and industrial waters.	The environmental laws and ordinances should be enforced.
Providing appropriate drainage in the upper areas put the lower areas at risk as they get more water through LBOD and the dhoros. Protecting the lower areas from high water discharges in LBOD and the dhoros, means longer periods of flooding or no storm drainage. The population from the lower areas may try to block the implementation of the schemes.	Participatory approaches during implementation should be emphasized.
Population may encroach again in the dhoro waterways	The relevant authorities should be vigilant and should not allow any encroachments or blockages of the dhoros.

E CONCLUSIONS AND RECOMMENDATIONS

The RMP was prepared over a 3 year period, 2010-2013, to study drainage and environmental issues, problems, and possible solutions to flood problems and sustainable management of related technical, economic, social and environmental aspects. Based on extensive consultations, surveys, workshops, and meetings with a wide range of stakeholders, several possible project interventions were identified and studied. As a result of the detailed feasibility analyses, five investment projects were identified that met the criteria of sustainability, high economic return, and high likelihood of being implemented as designed. The five proposed projects include i) rehabilitation of LBOD, ii) revival of natural waterways and storm drains, iii) mangrove plantation in coastal areas, iv) rehabilitation of Deh Akro II and Chotiari wetlands, and v) forest plantation using drainage water (pilot).

It is recommended that these five projects be financed as soon as possible, given the urgency of addressing the flood, drainage, and environmental threats prior to another major climatic event and flood taking place in the study area. Priority works can be undertaken immediately. Based on the financial resources available, other works can continue on an annual basis. Every effort should be made to seek international development partner financing. The participatory approach, adopted throughout the

preparation of this RMP, should be adopted during project implementation, monitoring, and evaluation.

The EIRR for the two core components, the rehabilitation of the LBOD, revival of the dhoros along with the construction of the storm water drains is estimated as one complementary intervention. Notwithstanding the benefits from the three subcomponents are not equal, and not commensurate with the individual investment outlays, as it is difficult to isolate the individual contribution, the benefits and the cost of the three subprojects have been evaluated as one investment option. However, if the benefits are assumed equal, it would be worthwhile to give higher priority to the rehabilitation of LBOD, along with the reactivation of the dhoros located in left bank of the LBOD system (so that the offloading pressure on the LBOD is achieved). This can be followed by the reactivation of dhoros located on the right side of the LBOD, and construction of storm water drains in the leftover areas within the left bank of Indus.