Water Assessment of Nari River Basin and Water Policy Issues of Pakistan

A document based on objective study aimed at 'Support to Development of Country Policies

Country Policy Support Program (CPSP)

Project funded by

Sustainable Economic Development Department
National Policy Environment Division
The Govt. of The Netherlands
(Activity No.WW138714/DDE0014311)

ICID•CIID

INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (ICID)
NEW DELHI

December 2005

International Commission on Irrigation and Drainage (ICID) was established in 1950 as a Scientific, Technical, Non-commercial, Non-Governmental International Organisation (NGO) with headquarters at New Delhi, India. The Commission is dedicated to enhancing the worldwide supply of food and fiber by improving water and land management, especially the productivity of irrigated and drained lands. The mission of ICID is to stimulate and promote the development and application of the arts, sciences and techniques of engineering, agriculture, economics, ecological and social sciences in managing water and land resources for irrigation, drainage and flood management using research and development, and capacity building. ICID aims to achieve sustainable irrigated agriculture through integrated water resources development and management (IWRDM). ICID network spreads to 105 countries all over the world.

Country Policy Support Programme (CPSP) was launched by ICID in 2002 to contribute to develop effective options for water resources development and management to achieve an acceptable food security level and sustainable rural development. The programme is implemented in five countries viz. China, India, Egypt, Mexico and Pakistan and is funded by Sustainable Economic Development Department, National Policy Environment Division, The Govt. of The Netherlands as Activity No.WW138714/DDE0014311.

ISBN. 81-89610-02-3

The external boundaries of Pakistan as depicted on the map in this report are not political

ACKNOWLEDGEMENTS

The present study was conducted as part of Country Policy Support Programme initiated by the International Commission on Irrigation and Drainage (ICID) under the financial assistance of Sustainable Economic Development Department, National Policy Environment Division, Ministry of Foreign Affairs, The Government of The Netherlands.

ICID acknowledges the support it received for the conduct of the various studies under CPSP from many water related International Organisations by way of their participation in consultations and dialogues during the different phases of the study. The outcome of studies was shared with IWMI, FAO, WWF, IUCN and GWP from time to time. During the National consultation many valuable suggestions and comments were received from several stakeholders, which helped greatly in in-depth review of the analysis and results of the specific studies. These contributions are gratefully acknowledged.

ICID acknowledges the constant guidance and support it received from President Peter Lee and Presidents Honoraire Ir. Keizrul bin Abdullah and Prof. dr. Bart Schultz in overall implementation of CPSP activities in participating countries. The initiative of Dr. C D Thatte, Secretary General Honoraire enabled to conceptualise the activities and a fillip to CPSP initiatives. A team comprising Mr. A.D. Mohile, former Chairman, Central Water Commission (CWC), India, and Mr. L.N. Gupta, former Executive Director, WAPCOS (India) contributed to the development of a Basin-wide Holistic Integrated Water Assessment (BHIWA) model and supported the Pakistan National Committee on Irrigation and Drainage (PANCID) in its application to Nari river basin.

ICID assigned the CPSP study to PANCID in collaboration with National Engineering Services Pakistan (NESPAK), Lahore. ICID acknowledges the support Mr. I.B. Shaikh, Chairman, Pakistan National Committee on Irrigation and Drainage (PANCID), and Chairman, Federal Flood Commission (FFC), Govt. of Pakistan and Mr. Nasim Bazai, Chief Engineer Irrigation (South), Irrigation and Power Department, Government of Balochistan in carrying out this study successfully. ICID wishes to express their sincere appreciation to NESPAK study team especially to Mr. Nasiruddin (Team Leader) and Mr. Shehzad Ahmed (Modeller) for their dedicated and valuable input. At the Central Office, ICID, Dr. S.A. Kulkarni, Director (I) ably coordinated the execution of various CPSP activities since its inception and edited the report for printing. Their contributions are duly acknowledged.

ICID acknowledges the donors for reposing their confidence in ICID in assigning the task of exploring strategic directions to support county level policy for addressing water supply and demand issues of all the three sectors in an integrated, holistic and sustainable manner with food security and rural development as the main focus.

M Gopalakrishnan

December, 2005 *Secretary General*

PROJECT PARTICIPANTS

Pakistan National Committee of ICID (PANCID)

1. Dr. I B. Shaikh, Chairman, PANCID and Chairman, Federal Flood Commission (FFC)
2. Mr. Alamgir Khan, Superintendent Engineer, FFC
3. Mr. Javed Iqbal Bokhari, Deputy Engineering Advisor, FFC

National Engineering Services Pakistan (NESPAK) Team

1. Mr. Nasiruddin, Study Team Leader
2. Mr. Shehzad Ahmed, Numerical Modeler
3. Mr. Muhammad Kaleem Ullah, Numerical Modeler
4. Mr. Rafaquat Ali, Hydraulic Engineer

Balochistan Province, Pakistan

1. Mr. Naseem Bazai, Chief Engineer Irrigation (South), Irrigation & Power Department
2. Mr. Kamran Babar, Director, Cameos Consultants
3. Mr. Asad, Cameos Consultants

ACRONYMS / ABBREVIATIONS

ACE	Associated Consulting Engineers
AWB	Area Water Board
BAU	Business as Usual
BCM	Billion Cubic Meters
BHIWA	Basin-wide Holistic Integrated Water Assessment (Model)
Cfs	Cusecs (Cubic feet per second)
CPSP	Country Policy Support Program
D&I	Domestic and Industrial
DMP	Drought Management Plan
EFR	Environmental Flow Requirements
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ET	Evapo-transpiration
FAO	Food and Agriculture Organization
FFC	Federal Flood Commission
FO	Farmer's Organizations
GAMS	General Algebraic Modelling System
GEF	Global Environmental Facility
GW	Groundwater
IBMR	Indus Basin Model Revised
ICID	International Commission on Irrigation and Drainage
IFPRI	International Food Policy Research Institute
IIMI	International Irrigation Management Institute (now IWMI)
IIMS	Integrated Information Management System
IRI	Irrigation Research Institute
IRSA	Indus River System Authority
IT	Information Technology
IWASRI	International Waterlogging and Salinity Research Institute
IWMI	International Water Management Institute
IWRDM	Integrated Water Resources Development and Management
LPCD	Litre Per Capita Per Day
MAF	Million Acre Feet
Mha	Million Hectares
mm	Millimetres
Mm^3	Million cubic meters
MT	Million tons
NESPAK	National Engineering Services Pakistan
NGO	Non-Government Organization

NSDS	National Services Drainage Projects
NWFP	North Western Frontier Province
NWP	National Water Policy
PANCID	Pakistan National Committee on Irrigation and Drainage
PARC	Pakistan Agricultural Research Council
PCRWR	Pakistan Council of Research in Water Resources
PIDA	Provincial Irrigation and Drainage Authority
PNC	Pakistan National Consultation
PODIUM	Policy Dialogue Model
PPM	Parts per million
PWP	Pakistan Water Partnership
RBOD	Right Bank Outfall Drain
SB	Sub Basin
SCARP	Salinity Control and Reclamation Projects
Sq.Km	Square Kilometre
Sw	Surface water
TDS	Total Dissolved Salts
TRWR	Total Renewable Water Resources
UET	University of Engineering and Technology
UNDP	United Nation Development Programme
WAPDA	Water and Power Development Authority
WFFRD	Water for Food and Rural Development
WHO	World Health Organization
WWF	World Wide Fund for Nature
Yr	Year

EXECUTIVE SUMMARY

The World Water Vision on Water for Food and Rural Development (WFFRD) for the year 2025 formulated through extensive consultations held in over 43 countries was facilitated by International Commission on Irrigation and Drainage (ICID) among others. The World Water Vision document was presented at the 2nd World Water Forum held at The Hague, The Netherlands in 2000. A substantial increase in the global water withdrawal, water storage and irrigation expansion for the pre-dominant "*food sector*" (largely consumptive) was apparent. These projections of larger increases were in the developing countries. However, the integrated overview vision did not quite reflect these conclusions. It also did not reflect quantification of water needs for the "*people sector*" (largely non-consumptive) and the "*nature sector*" (largely consumptive).

In order to integrate the supply and demand of all the three sectors, namely-food, people and nature, ICID adopted a 'Strategy for Implementation of Sector Vision on Water for Food and Rural Development' in the year 2000. ICID also felt the need to mobilise strong international support for the strategies and policies after necessary independent assessments. In line with this, ICID launched a project titled "Country Policy Support Program (CPSP)", with a funding support from the Government of The Netherlands.

China, Egypt, India, Mexico and Pakistan having 43% of the world population and 51% of the world irrigated areas were chosen as participating countries in the CPSP. Through CPSP an attempt was made for a detailed assessment of the water supply-demand situation for the three sectors. To begin with, two representative river basins of the two most populous countries of the world, viz., China and India were taken up for assessment and subsequently studies were taken up in Egypt, Mexico and Pakistan. Multi-stakeholder consultations at the respective basin and national levels were held and the findings from such consultations helped to identify desired interventions in the national policies related to water resources development and management.

As part of the CPSP study in Pakistan, Nari river basin was selected for assessment. The Nari River flows in the Balochistan province of Pakistan, and terminates in the Kachhi plains, on which the waters of the Nari and other hill torrents debouch. ICID facilitated a National Level Consultation in Lahore, Pakistan, to present and discuss the output of assessment of the Nari River Basin. The consultation was organized by Pakistan National Committee on Irrigation and Drainage (PANCID) with the help of National Engineering Services of Pakistan (NESPAK). Participants representing different regions and disciplines discussed policy interventions emerging from these studies and their implications for addressing country level problems in water management at length.

A Basin-wide Holistic Integrated Water Assessment (BHIWA) model evolved by ICID was used in basin study. The present total surface withdrawals in the Nari basin are 140 million cubic meters (Mm^3), which is 10% of the total inputs to the surface water system, whereas the return flows contribute 3% of the total inputs. The contribution of return flows to the surface water system is not to such an extent to cause risk of pollution for downstream users. For the future scenarios, the amount of surface water withdrawals will vary from 80 to 309 million cubic meters. The highest amount of surface water withdrawals (309 Mm^3) will be under business as usual (BAU) scenario, which comprises 23% of the total inputs to the surface water-body system. In all the future scenarios, water demands for people will be competing with other sectors. With the population growth rate of 2.38%, this demands would increase to 33 Mm^3. This will also cause stress to groundwater, if major portion of it is to be met from the groundwater source. At present the industrial water demands in the Nari River Basin are nominal.

Groundwater resources of the Nari River Basin are very limited and a few sub-basins have already been over drafted. In the current situation, groundwater withdrawals are 84 Mm^3, which is 54% of the total inputs to groundwater system. Total inputs include natural recharge from rainfall and return flows from irrigation and domestic and industrial water use. This amount of groundwater withdrawals will vary from 84 Mm^3 to 366 Mm^3 under various future scenarios. Presently the amount of base flow contributing to river flows is 84 Mm^3 which will reduce to as low as 10 Mm^3 under various future scenarios. Any groundwater development activity in the basin will reduce the amount of base flow moving towards basin outlet for downstream users. The groundwater outputs inclusive of base flow under present situations are 108% of the total inputs, which will further increase to 164% under business as usual scenario. The return flow under various scenarios will vary from

31% (Present) to 55% (BAU), thus causing risk of quality hazards to downstream water users.

Presently, the total consumptive use in Nari River Basin is 1072 million cubic meters. It comprises of nature sector (895 Mm^3), agricultural sector (172 Mm^3) and people sector (6 Mm^3). The agricultural water use of 172 Mm^3 in rain-fed as well as irrigated lands is met from rainfall, soil moisture and irrigation. The total consumptive use in nature and agricultural sectors includes considerable non-beneficial evapo-transpiration (ET) of 553 Mm^3 and 43 Mm^3 respectively. The reduction of non-beneficial ET through rainwater harvesting and soil water management can lead to a significant improvement in flows. In the BAU scenario, total ET is likely to be 1,371 million cubic meters. In different future scenarios the amount of consumptive use varies from 1,050 to 1,371 million cubic meters. Three future scenarios (II, III &VI) emphasize on better water resources management without increasing the crop area, whereas all the other future scenarios are accomplished with increase in crop area to cope with the increasing food demands.

The amount of return flows to groundwater also varies from 2% to 10% of the total inputs for different scenarios. The highest amount of return flow (10%) will be under BAU scenario, which will be causing severe risk of pollution to downstream waters.

The water demands for agriculture, people and nature sector is met primarily from the surface water resources in the Nari River Basin. When the surface water is not available, additional pumping from groundwater to surface canals is required to be done to fulfil the crop and domestic and industrial water demands in the area. The amount of groundwater pumping to surface canals will vary from 31 to 227 million cubic meters in different future scenarios. This additional pressure on groundwater resources will be met through the natural and induced recharge from surface flows. The amount of this recharge will vary from 50 to 98 million cubic meters. This recharge will be available through various development activities including delay action dams, diversion structures and storage dams.

About 61% of the river flow occurs during the two months of July and August. This unobstructed water sometimes causes flood like situation in the downstream reaches of the Nari River Basin, causing severe loss to property and lives of people and livestock. Therefore, the construction of small and medium storage reservoirs of 544 Mm^3 total capacity could be helpful for flood mitigation measures and to attain more reliable surface water supplies in the dry months of the years.

The study has indicated that there is huge development potential of surface water resources in Nari River Basin. For an average condition, the outflow to basin outlet is 1050 Mm^3. A considerable part of it can be stored by constructing delay action dams, diversion structures and storage dams to fully utilize the potential water resources.

It was also felt that there is strong need to extend this study to Indus River Basin to identify desired interventions in the national policies related to water resources development and management.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of Country Policy Support Program

The formulation of World Water Vision on Water for Food and Rural Development (WFFRD) for year 2025 was facilitated by ICID amongst others, through extensive consultations held in over 43 countries, for inclusion in the World Water Vision presented during the World Water Forum (WWF2) at The Hague. While this vision projected substantial increase in the global water withdrawal, water storage, and irrigation expansion for the pre-dominant **'food sector'** (largely consumptive), much larger increases were projected in the developing countries, but the integrated 'overview vision' unfortunately did not reflect these conclusions. It also did not reflect lack of quantification of water needs for the other two sectors viz. **'people'** (largely non-consumptive) **and 'nature'** (largely consumptive), while making large claims. *Not only claims were made for larger allocations, demands were made for diversion of water from food sector to others claiming inefficiency and scope for reduction, also for not building any more dams, for only demand management and going in for Watershed Management.* A generic diagram is shown in Figure 1 indicating relevance of population spread, rainfall (precipitation), fair weather flow to the sectoral needs for food, people, terrestrial and aquatic eco-systems. It shows incidence of these aspects from basin boundary to delta / mouth region. Food sector needs are in proportion of population spread, so also the needs of people sector. Needs of terrestrial eco-systems match with precipitation, whereas needs of aquatic eco-systems match with fair weather flow.

Figure 2 shows stream orders in a typical river basin. For tropical basins with arid to semi-arid climate, it is seen that

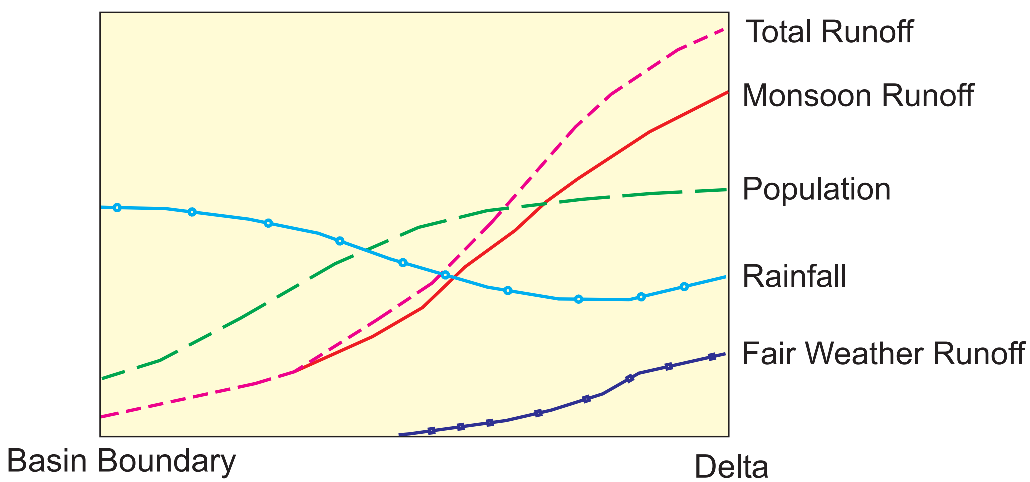
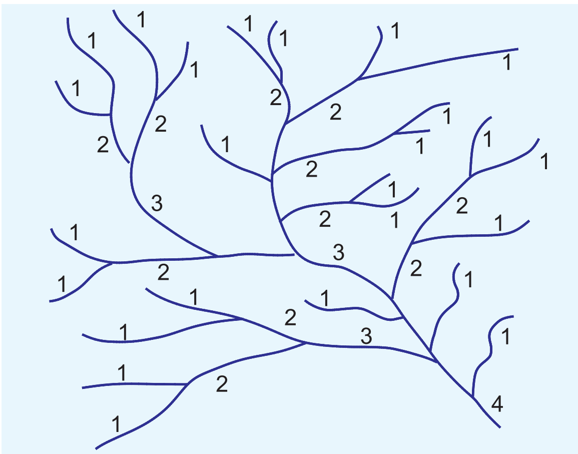


Figure 1 River Basin - Water for Food, People and Nature Sector Inter-relations - A Generic Diagram

only stream orders 3 and 4 carry fair weather flow which allows habitat for aquatic eco-systems



Stream Orders of a Fourth-Order stream

Figure 2 Stream Orders in a Typical River Basin

1.1.1 ICID Strategy and Evolution of CPSP

To address reasons for such differences and taking further logical steps for integration of supply demand sides for all the three sectors, ICID adopted a 'Strategy for Action' in the year 2000. It was found that several developing countries already had adopted water policies, which were reflected in this 'strategy'. ICID felt the need to mobilise strong international support for the strategy and policies after necessary independent assessments. ICID therefore formulated a project titled as "Country Policy Support Programme (CPSP)". IWMI and IFPRI joined the effort as they were enthused by the adoption of PODIUM and the likely use of the newly integrated PODIUM and IMPACT models. FAO (IPTRID) and World Bank also decided to support the effort for specified contributions.

1.1.2 CPSP and Dialogue

While ICID was firming up its CPSP proposal, an international initiative sponsored by a consortium of 10 participating organisations was launched in August 2001 to conduct a 'Dialogue on Water, Food and Environment'. While the concept of holding consultation at various levels is included both in the 'Dialogue' and 'CPSP', the former has a focus on building bridges between the bipolar water needs for food and environment, without accounting for the **critical role of 'Water for People' sector**, in its impact on environment. The latter on the other hand focuses on: the need for scientific assessments, the need for improvement of analytical tools such as PODIUM and IMPACT models, the scope for involvement of National Governments and funding agencies, the funding and stakeholder institutional mechanisms, and more importantly on recognition of an integrated approach for evolution of water policies for the three sectors.

The needs for water for 'Food' and 'People' sectors are mounting with continued growth of population. The consumptive requirement of the former far outweighs that of the latter. So also the development and abstractions. The people sector did not attempt in past perspective plans for development of its own resources through dedicated storages, largely riding piggyback on the former sector. Also, little has been done to evaluate basin-wise needs for 'Nature' sector, while claiming shortages and blaming the other two sectors for such needs. The quantification forms a core activity of the CPSP. While the Dialogue lays special stress on local actions, the CPSP relies on basin and national level consultations to be able to provide support to the country policies on macro scale. The CPSP thus is slated to be a major contribution of ICID to the water sector. Incidentally its output was found useful for the 'Dialogue'.

1.1.3 CPSP Study in China and India

The CPSP envisages a detailed assessment of the water supply-demand situation for the three sectors in a couple of representative river basins of the two most populated countries of the world, viz. China and India for conditions as in the past, as at present and as likely in future. Based on such assessments, multi-stakeholder consultations at the respective basin and national levels, and the use of findings from such consultations for identifying interventions in the national policies related to water resources are also envisaged. The CPSP specifically addresses future water scenario for food and rural development, water for people as also water for nature, in an attempt to integrate them in the broader context of Integrated Water Resources Development and Management (IWRDM) to achieve sustainable development and use of the water resources.

1.2 CPSP Study in Pakistan

Under the CPSP program, a Basin-wide Holistic Integrated Water Assessment (BHIWA) model was developed by ICID, and was applied to two basins each in China and India. As a part of CPSP, preliminary assessments for sample basins in Egypt, Mexico, and Pakistan were made. For this purpose, orientation workshops were organized in Egypt (August, 2004) and New Delhi (December, 2004). PANCID selected the Nari basin for assessment, and constituted a study team. The basin is located in the Balochistan province of Pakistan, and terminates in the Kachhi plains, on which the waters of the Nari and other hill torrents spread. An exclusive workshop for the PANCID study team members was organised in January/ February 2005 at New Delhi, followed by a preliminary assessment of Nari basin, with assistance of CPSP Central Team.

As part of the CPSP activities ICID facilitated a National Level Consultation in Pakistan, to present and discuss the outcome of the preliminary assessment of Nari basin. The consultation was organised by Pakistan National Committee on Irrigation and Drainage (PANCID) with the help of National Engineering Services of Pakistan (NESPAK). In the consultation, participants representing different regions and disciplines discussed policy interventions emerging from these studies and their implications for addressing country level problems in water management at length. A list of participants of the consultation is given in Annex 1. The participants from international organizations included those from ICID, IUCN, WWF, IWMI and IWASRI. The organisation and discipline wise break-up of the invitees / participants is given below:

Discipline-wise Classification of Participants

Engineering	51
Agricultural Sciences	9
Water Quality & Environment	5
Hydrologists	4
Modellers	4
Administrators	3
Development Planners	2
Total	**78**

Organisation- wise Break up of Participants

Federal Government	10
State Government	20
Consultants (Public Sector)	20
Consultants (Pvt. Sector)	5
Academics & Institutes	8
NGOs & Individuals	15
Total	**78**

CHAPTER 2

WATER RESOURCES OF PAKISTAN AND BALOCHISTAN

2.1 Water Resources and Food Demand of Pakistan: Present and Future Projections

The water resources of Pakistan are the natural precipitation, the surface water and the groundwater. In the arid to sub-tropical climate of the country, the natural precipitation is scanty. Over half of the country receives less than 200 mm of annual rainfall, and rainfall in excess of 400 mm occurs only in about 20 percent of the northern areas. Apart from being scanty, the precipitation is distributed quite unevenly over the seasons and in a major part of the country. This is concentrated in 3 to 4 months of the summer monsoon. Despite its meagre amount, this rainfall is utilized for rainfed agriculture, drinking water needs of the people and livestock and it contributes to the livelihood of a small but vulnerable portion of the population

The principal source of surface water available to Pakistan is its rivers. Most of these rivers, in the western half of the country, are ephemeral streams that remain dry for most of the year. It is the Indus River and its tributaries with perennial flows that constitute the main source of water supply. The Indus and its tributaries have their sources in the Himalayan Mountains and the Hindu Kush, which extends beyond the country's territorial limits (PWP, 1999). Pakistan's total renewable water resources are 234 billon cubic meters (BCM). Table1 shows the composition of available water resources of Pakistan.

Table 1.
Total Renewable Water Resources of Pakistan (TRWR), (BCM/year)

A) Water resources produced internally (In a 10th frequency dry year)	
• Surface water	47.4
• Groundwater	55.0
Total internal renewable water resources	**102.4**
B) External renewable surface water resources	
• Surface water entering the country	181.4
• Surface water leaving the country	6.7
Total external water resources (natural)	**181.4**
C) Total Renewable Water Resources (TRWR)	
• Surface water: total	228.8
• Groundwater: total	55.0
• Overlap	50.0
Total water resources	**233.8**

(Source: http://www.fao.org/ag/agl/aglw/aquastat/water_res/pakistan/pakistan_wr.xls)

The surface irrigation system, which covers the largest contiguous area, comprises of three storage reservoirs, 16 Barrages, 12 link canals, 43 main canals and 134,000 watercourses. At present 131 billion cubic meters water is diverted for irrigation purpose.

The average annual inflow of the Western Rivers at the rim station as they enter the Indus Plains is 172.70 BCM (140 MAF). Although the surface flows of the Indus river and its tributaries available to Pakistan are quite significant these are characterized by a great variation.

In addition to the surface water, groundwater is another important source of water supply. Investigations have established the existence of a vast aquifer with an area extent of 194,000 sq. km underlying the Indus Plains which has been recharged in the geologic times from natural precipitation and river flows and more recently by the seepage from the canal systems. Although the quality of the groundwater in the Indus Basin aquifer is highly variable, both spatially and with depth, it is estimated that 67.85 BCM (55 MAF) of groundwater representing the safe yield, could be withdrawn annually for beneficial uses[1] .

Presently, Pakistan is a water scarce as well as food grain deficit country. Its total crop production is less than its internal requirements. To meet the food requirements of the ever-increasing population of the country, a large amount of food grains are being imported every year from various parts of the world. To fulfil the dream of self sufficiency in food items, there is a need for full utilization of land and water resources keeping in view the sustainability of these resources and eco-system. Figure 3 shows the gaps between the demands and production of food grains for present and future years.

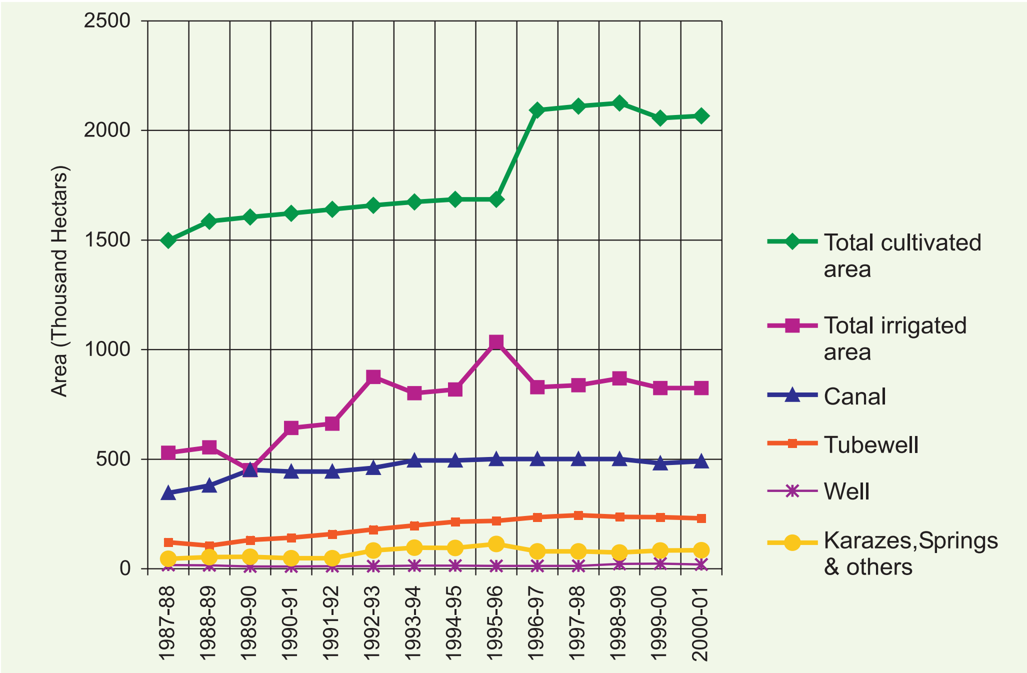
2.2 Water Resources of Balochistan

Balochistan province has the largest area amongst the four provinces of Pakistan (approximately 350,000 km^2 which is about 43% of total area of Pakistan) but has the lowest inhabitants (7 million). The province derives its name from the Baloch, one of the three main socio-linguistic groups in the Province. Balochistan extends between the northern latitudes 24^0-32^o and thus lies completely north of the tropics. The longitudes of 60^o to 70^o east enclose Balochistan. Topographically Balochistan is the eastern extension of the Iranian plateau, subdivided by high (2,000-2,500 m) to moderately high (1,000-2,000 m) mountain ranges limiting accessibility. The highest mountain, Loe Sar, has an elevation of 3,520 m. Four climatic zones (Coastal, Tropical, Sub-tropical and

(Source: PWP, 1999)

Figure 3 Food Grain Demand and Requirements in Pakistan

[1] PWP, 1999, Pakistan Water Vision



(Source: Development Statistics of Balochistan, 2000-01)

Figure 4. Area Irrigated by Different Sources in Balochistan

Temperate) are found in the province. The range of altitude and temperatures permit the cultivation of wide range of cops, which contribute to the diversity of agriculture in the Province. However the limited availability of water resources on account of runoff at present restricts the amount of land under cultivation. At present, approximately 1.6 million hectares are in various forms of cultivation (less than 5% of the total area). Of these about 837,000 ha are actually under production, comprising 96% irrigated and remaining 4% rainfed area. The province is badly in short of irrigation facilities. Of the entire province, only 0.8 Mha get the irrigation supplies. The main sources of irrigation are:

- Government and Private Canals
- Well and Tubewells
- Karezes and springs

Figure 4 shows the area irrigated by various irrigation sources in Balochistan. Wheat and rice are the two dominant field crops in the Province. Wheat occupies approximately 71% of total area under crops during Rabi (winter) season, whereas rice occupies 37% of total area under kharif crops.

Hill torrents of Pakistan encompass over 65 percent area of Pakistan including the entire Province of Balochistan. The annual precipitation in Balochistan ranges from 300-400 mm in the north-western regions, while it varies from 75-100 mm in the south-western sections. Average annual rainfall of Balochistan is 158 mm. Hill torrents of Balochistan generate on the average, 9680 Mm^3 runoff as shown in Table 2.

2.3 National Water Policy (Draft)

Water resources management and development in Pakistan faces immense challenges for resolving many diverse problems. The most critical of these is a very high temporal and spatial variation of water availability. Nearly 81 % of river flows and 65% of precipitation occurs during the three monsoon months, while quality of groundwater largely varies with depth and location. Ever expanding water needs for the growing economy and the population for meeting its food and fiber requirements, and the advent of frequent floods and droughts, add to the complexity of water management.

The sustainability of irrigated agriculture and its further expansion is being threatened by a number of issues including the following:

Table 2.
Basin-wise Water Availability in Balochistan

River Basin	Area (Sq.Km.)	Avg. Rainfall (mm)	Runoff (Mm3)	Water availability for different return periods (Mm3)			
				2.33-Yr	5-Yr	10-Yr	25-Yr
Indus Basin Component							
Kundar	2,297	125	189	189	234	285	340
Zhob	15,540	225	944	1,133	1,360	1,609	1,889
Mari Bugti	14,608	175	467	467	738	957	1,205
Talli/Chakkar	2,064	175	65	65	79	109	132
Bolan & Mula	5,340	175	207	719	1,215	1,618	2,195
Pishin & Sariab Lora	11,978	175	764	764	1,039	1,268	1,566
Upper Kaha Hill Torrents	5,540	300	303	NA	NA	NA	NA
Musa Khel	5,437	300	464	464	557	696	835
Nari	22,560	154	1,180	1,050	1,504	1,874	2,342
Kharan Closed Desert							
KCB Basin	97,440	100	0.97	0.97	1.14	1.42	1.70
Makran Coastal Basin							
MCB Basin	123,025	150	3.69	3.69	4.30	5.44	6.52
Balochistan (Total)	**347,190**	**158**	**9,680**	**9,680**	**11,300**	**14,170**	**17,000**

(Source: Master Feasibility Study for Flood Management of the Hill Torrents of Pakistan)

- Growing need of water to meet requirements of rising population besides socio-economic demands,
- Very high variations, both in terms of space and time, in the availability of water resources,
- Reduction in the availability of surface water, due to silting of dams,
- Lack of proper maintenance of the canal system leading to unsatisfactory service,
- Waterlogging and salinization of areas in various canal commands of Indus Basin System,
- Lack of commitment by various organizations on the need for provision of drainage network as a part and parcel of the irrigation network,
- Over exploitation of groundwater resources, thus, rendering large areas out of reach of poor farmers and exhaustion of groundwater aquifers,
- Pollution of aquifers due to lateral movement of saline water or upward movement of highly mineralised deep water,
- Lack of proper disposal of saline effluent,
- Contamination of river water due to disposal of industrial waste, household wastewater and field overflows contaminated with fertilizer and pesticides,
- Inadequate participation of consumers,
- Frequent floods and droughts,
- Lack of inter-provincial consensus on developmental strategy and mistrust between provinces on equitable water distribution,
- Proper pricing/valuation of water, and
- Quality of water in all sub-sectors.

The proper development and management of water resources should serve as a platform to initiate other development activities and should unlock the gateway for a full range of development of contemporary resources. If nothing is done to enhance food production, there will be an inevitable threat of famine in the country, sooner or later.

The development of water resources is sustainable only if it meets the needs of the present without compromising the ability of the future generations. Pakistan has entered the 21st century with a formidable challenge in water resources development, resource use efficiency and environmental protection, in which the availability of water for household use and food production will continue to remain dominant. The detailed National Water Policy (Draft) is kept at Annex 2. The National Water Policy highlights and focuses on the change in concepts, policies, planning approaches, institutional framework and mechanisms to achieve sustainability, proper development and optimal benefits from this resource.

2.4 Nari Basin Water Assessment

Nari river basin is a groundwater deficit basin having considerable intensive agriculture, fairly large population and comprising of major cities of the province. The river debouches into Kachhi plains along with many other hill torrents. The water accumulated in the Kachhi plains during floods could damage the Pat Feeder canal of the Indus and its command in the Sindh and Balochistan provinces. A drain has been built to lead the water into Muncher Lake, which both receives supplies from and drains into the Indus.

The region, in general, receives precipitation in summer and winter from monsoon and western disturbances respectively. In the upper, north-western parts of the basin, the winter precipitation, partly as snow, is more predominant: whereas in the lower parts, the summer (south-west) monsoon predominates. The average annual rainfall is of the order of 154 mm and annual average runoff at the terminals is 1180 Mm^3. The present surface and groundwater uses in the basin are estimated at 133 Mm^3 and 51 Mm^3 respectively.

2.5 Studies Using BHIWA Model

The Basin-wide Holistic Integrated Water Assessment (BHIWA) model specially developed by ICID was used for assessment of Nari basin. A brief description of BHIWA model is given in Annex 3. A brief note on application of BHIWA model to Nari River Basin is kept as Annex 4.

For assessment purpose, the Nari basin has been divided into three sub-basins as follows:

SB1:	Anambar sub-basin upto Ghatti Bridge (Area: 6,768 sq.km)
SB2:	Beji and Dabar sub-basins upto Babar Kach (Area: 7,347 sq.km)
SB3:	Loe Manda and Khost sub-basins upto Sibi Bridge (Area: 7,445 sq.km)

The model was calibrated using hydrological and other data for a five-year sequential run (1997-1998 to 2000-2001). Seven scenarios of future-2025 were studied alongwith present situation and business as usual scenario using the calibrated model including scenario for making the current groundwater use sustainable.

A short description of IV to VIII scenarios is given below:

S. N o.	Abbreviation	Explanatory Note
1	Present (2001)	To date
2	BAU	Business as usual: with past trends
3	Future-IV	Little storage of 127 Mm^3 with shift in cropping pattern
4	Future-V	Little storage of 127 Mm^3 with cropped area increase as BAU
5	Future-VI	More storage of 544 Mm^3 for flood control and no increase in area
6	Future-VII	More storage of 544 Mm^3 and shifting cropping pattern to have more irrigated rabi crops.
7	Future-VIII	Medium storage of 190 Mm^3 and increasing forest area

The total water withdrawals aggregated over the basin is estimated at 242 million cubic meters. This is expected to increase to 709 million cubic meters n 2025 under the BAU scenario.

Sectorwise Use

The ICID's CPSP focuses on water use for Food, People and Nature Sector, in an objective manner based on the model results, one obtains consumptive use by different sectors under present and BAU scenario as follows:

(Mm^3)

Use sector	Present	BAU
Nature sector	894	881
Agriculture sector	172	479
Domestic & Industrial (D&I), People sector	6	12
Total	**1,072**	**1,372**

2.6 Findings of the Basin Assessment Study

The main findings of the Nari Basin assessment are as follows:

1. In all the future scenarios, water demands for people will be competing with other sectors. With the population growth rate of 2.38%, this demands would

increase to 33 Mm^3. This will also be causing stress to groundwater resources, if major portion of it is to be met from the groundwater source. At present the industrial water demands in the Nari River Basin is nominal. If there would be a major shift in policies to have industrial zones in the Nari Basin area, the agriculture would confront the crisis of water shortage increasingly.

2. The model output shows that there is huge development potential of surface water resources. On an average condition the outflow to basin outlet is 1050 Mm^3. Out of this amount a considerable fraction can be stored through construction of delay action dams, diversion structures or storage dams to fully utilize the potential surface water resource.

3. About 61% of the river flow occurs during the two months of July and August. This unobstructed water sometimes causes severe flood like situation in the downstream reaches of the Nari River Basin, causing severe loss to property and lives of people and livestock. So for the flood protection measure, construction of small and medium storage reservoirs of total capacity of 544 Mm^3 could be helpful for flood mitigation measures and to attain more reliable surface water supplies in the dry months of the years.

4. Groundwater resources of the Nari River Basin are very limited. Out of nine sub-basins of the Nari River Basin, only three have shown the availability of groundwater to some extent. Few sub-basins have already shown mining situation especially in SB-I, where extensive use of groundwater for irrigation is causing threats to groundwater system as well as quality hazards for downstream users.

5. The amount of base flow (groundwater flow contributing to river flows) will be reducing under various future scenarios; the lowest will be under future-VIII, where full potential of water resources will be utilized to increase the crop area. This decrease in base flow will result in groundwater storage, although system ground water balance will be achieved through the concept of artificial recharge. This reduction in base flow signify the crisis of groundwater deterioration.

2.7 Issues for Discussion

The following issues were put forth before the participants during the National Level Consultation to get their feed back.

- *Integrating surface and groundwater usages*
- *Integrating flood control with use of water*
  - Construction of reservoirs with dams
- *Integrating food, agriculture and irrigation*
  - Use of drip and sprinkler irrigation systems
  - Expansion of horticulture – possibility of commercial advantages ?
  - Mechanization and privatization
- *Water supply*
- *Ecology – quality enhancement requirements*
  - Integrating ecological requirements with water uses
  - Lake ecology – any enhancement possibility by specific flow releases
- *Downstream and upstream issues*
  - Additional irrigation in Nari basin
  - Flood control
- *How Nari development can address ecological problems of Nari / Kachhi plains /Manchar Lake / Indus*
  - Type of damages due to floods: agricultural lands only
  - Can increased watershed treatment be of use?
  - Reduce flood peaks upto a threshold level may be to advantage though above that level, floods can cause damage
- *Land use plans - future possibility*
- *Recharge with the creation of storage upto 500 Mm^3 (Storage possibilities are yet to be established)*

A View of Nari River near Sibi Showing Perennial Flow.

A View of Nari River at Mithri.

(The fields seen in the background are irrigated from the river water;
The pumps seen in the foreground are used for irrigating fields near river bank.)

CHAPTER 3

ISSUES EMERGED FROM NATIONAL CONSULTATION

3.1 Nari Basin Studies

3.1.1 Storage Dam Sites in Nari Basin

Eighteen sites have been proposed for the management of floods in Nari Basin. The proposed plan consists of Delay Action Dams, Detention/Storages Dams and Dispersion Structures with Diversion Channels. While recommending a diversion structure the main consideration is the perennial flow in the streams and the existing irrigation of the area. With the proposed diversion structures it is intended to divert additional and ensured supplies

The purpose of delay action dam is mainly for the groundwater recharge in addition to moderation of flood peaks through reservoir routing and controlled releases through low level outlets specially provided to meet the requirements of local conditions. The flood peaks usually destroy the downstream storage or diversion structures and can fill the structures with sediments. Any development in Nari Basin could affect the downstream Kachhi plain, which utilize the water of Nari Basin. Construction of storage reservoirs and their effect on sediment movement and morphology of the hill torrents downstream of the reservoir, need to be studied.

3.1.2 Watershed Management and Sedimentation

Watershed area in the upper Indus Basin lying within Pakistan is about 24.5 million hectares. The major watersheds are in the northern areas in the North West Frontier Province (NWFP) and mountainous area of the province of Punjab[1]. There are few watersheds in Balochistan also. The rate of soil erosion in the watershed/ catchment areas of almost all the river basins in Pakistan is accelerating due to mainly over-grazing, deforestation, and cultivation of marginal lands and inability of people to undertake proper soil conservation measures and manage water effectively. There is an estimated 1.2 million hectares of eroded land in Pakistan. It is further estimated that 76 percent of Pakistan's land is affected, to varying degree, by wind and water erosion. In the NWFP province, the annual soil loss due to water erosion is estimated at an average of 2.5 tons per hectare on unprotected land while soil erosion on steeper slopes of Tarbela catchment has been estimated at about 40 tons per hectare per year. Average sediment load at Tarbela and Mangla Dam is 316 and 144 million tons per year[3].

Excluding the water-induced soil erosion within Sindh and Balochistan Province, some 38.31 million tons of soil enter the Indus Basin annually. In 1990, the Indus River carried the fifth largest sediment load in the world, estimated over the whole basin of 16 million hectare at 4.49 tons of silt per hectare. In the Tarbela catchment area, it has been estimated that 167 m^3/km^2/per annum of silt are produced[3].

Indus river system is bringing 500 million tons of silt every year. A better part of this sediment is intercepted by major reservoir, lakes, other water bodies and irrigation system. The live storage capacity of Mangla, Tarbela and Chashma Dam reservoirs is expected to be reduced by 33 percent by the year 2020. The soil erosion and sedimentation load can be reduced through proper development and efficient management of watersheds/ catchment areas. In the Nari basin, the afforestation and watershed management in the upper areas can provide a

[1] The International Institute for Environmental and Development (ODA), 1992. Environmental Synopsis of Pakistan

[2] Pakistan Water Partnership,1999, Pakistan Country Report Water Vision for the 21st Century

[3] IWMI, 1996, Severely Waterlogged Area in Pakistan (Unpublished Data)

strategy, which is complementary to the creation of storages for flood control. This needs to be studied.

3.1.3 Groundwater Depletion

The groundwater recharge in Pakistan is estimated to be about 67.85 BCM (55 MAF). It is being exploited through installation of 15,443 large public capacity (3-5 cusecs) and 469,546 small capacity (0.5-1.5 cusecs) private tubewells. The groundwater abstraction in Pakistan has increased from 4.12 BCM (3.34 MAF) in 1959 to 59.21 BCM (48 MAF) in 1996-97[2]. To meet ever increasing demand of water for agriculture, and water for domestic use and industry (people sector), more and more groundwater is being pumped. This is causing groundwater level to fall rapidly in many fresh groundwater areas. The mining of water is causing intrusion of saline groundwater into fresh groundwater areas resulting in deterioration of groundwater quality in many areas. In addition, pumping cost of groundwater increases as water table goes down. A study of Pishin Lora Basin in Balochistan province shows annual groundwater depletion of nearly 3 meters. Analysis of water table trend in the Indus Basin has shown the water table is going down in 26 canal commands out of 45 canal commands[4].

In the Nari Basin, few sub-basins have already been over drafted as discharge exceeding recharge. Some basins don't have any groundwater resources. So the need is to identify the sites having development potential in the basin. Sub-basin-1 is over drafted having about 11 Mm^3 more extraction than the recharge to the ground water system. Any surface and or groundwater development within the Bain could reduce the amount of base flow entering the other sub-basins as a link and/share resource.

3.1.4 Water Quality

The extensive use of groundwater in some parts of Nari basin would result in higher return flows to surface and groundwater due to the higher gradient, thus resulting in deterioration of water quality. The water of Indus River and its tributaries is of excellent quality. The total dissolved solids (TDS) range between 60 to 374 parts per million (ppm) which is safe for irrigated agriculture, domestic and industrial uses[5,3]. The TDS in the upper reaches at various rim stations range between 60 ppm during high flow to about 200 ppm during low flow. The water quality deteriorates downstream but remains well within permissible limits, with TDS in the water reaches of Indus (at Kotri Barrage) ranging from 150 ppm to 374 ppm, Tochi river at Tangi Post and Zhob river at Sharik Weir range between 400 ppm to 1250 ppm[6].

The indiscriminate and unplanned disposal of agricultural drainage effluent (polluted with fertilizers, insecticides, pesticides) and untreated sewage and industrial waste effluent loaded with BOD5, heavy metals and poisonous material into rivers, canals and drains cause deterioration of water quality in the downstream water ways and water bodies. According to a rough estimate, in 1995 some 9,000 million gallons of untreated waste water having 20,000 tons of BOD5 loading was daily being discharged into river, canals, drains and water bodies[7]. It was estimated that 350 and 250 million gallons per day was produced in Karachi and Lahore and most of which was discharged untreated into rivers, canals, drains and water bodies[8]. The polluted water of rivers, canals, and drains which is also being used for drinking downstream is responsible for numerous water borne diseases.

It is important that base flow leaving the downstream end of the Nari basin should be preserved to ensure continued supply to extensive surface water-fed schemes and other supplies from the Nari River Head works on the edge of Kachhi plain. However development of groundwater in the Nari basin should not result in reduction of downstream base flow.

3.1.5 CPSP Studies and Application of BHIWA Model: Suggested Policy Options

In regard to application of BHIWA model, the participants in general, agreed with the overall results of the application of the model. However, it was noted that there is room for improving the results. For example, in such low and highly variable rainfall regime, a weekly

[4] IWMI, 1996, Severely Waterlogged Area in Pakistan (Unpublished Data)

[5] Bhutta, MN. 1999. Vision on Water for Food and Agriculture Pakistan Perspective, Regional South Asia Meeting on Water for Food and Rural Development, New Delhi, June 1-3, 1999.

[6] IWASRI, 1997, Integrated surface and groundwater management programme for Pakistan- Surface Water Interim Report No.98/1

[7] Saleemi, MA, 1993, Environmental Pollution: Key Note Adress at the International Symposium on Environmental Assessment and Management of Irrigation and Drainage Projects for sustained Agriculture Growth, Lahore, 24-28 October, 1993.

[8] Hussain, M, 1995, Environmental Pollution

working, both for calibration and in simulation for assessment of scenarios, would be appreciated.

- In regard to results from scenarios studied the need for building additional storage at proposed dam site in Nari basin for multi purpose use was recognised. Specifically, as brought out in the BAU scenario, groundwater use under present conditions is unsustainable. The construction of additional storages, which would facilitate additional use of surface waters could remove the present imbalance between surface and groundwater uses.

- The afforestation and management of watersheds in upper reaches of the basin can be one of the strategies which can be complementary, or an alternative, to the strategy of creation of storage for flood control purposes.

- The water debouching on the Kachhi plains can cause damage in this area, and can also damage the irrigated areas between the plains and the Indus. Even though flood control is an important policy objective, slightly different strategies may cater for:

  - Flood control in the basin
  - Flood control in Kachhi plains, and
  - Flood control in canal commands.

- The ecological problems of the three areas would have to be addressed separately. For example -

  - While many supported mechanised (pumped) irrigation to allow maximum use of the waters, concerns about the ground water regime were also expressed.
  - While the need to eliminate flood damage was recognised, the need for maintaining the water regime and ecology of the Mancher- Indus system was also recognised
  - In the National context, the need for properly estimating the EFR of the Delta, receiving a high priority is a subject of study and debate, should be pursued vigorously.

3.2 Extrapolation and Applicability of Nari Basin Studies to Other Basins

Nari basin does not depict a typical sample of other river basins of the country. The extrapolation from the Nari Basin study at National level is debatable at this stage. The study has been carried out mainly by relying on the secondary data. The characteristics of Nari River basin are subject to quite variations from other basins in Pakistan.

Balochistan province consists of varying physiographic features and characteristics hydrological conditions. Prior to extrapolation to country level, more hydrological basins should be studied in detail.

3.3 Summary and Recommendations

Hydrologically, the province has three basins namely, Indus Basin Component, Kharan Closed Desert Basin and Mekran Coastal Basin. These basins could be further sub-divided into 73 sub-basins. Nari Basin is one of them. Nari River Basin is a ground water deficit basin; although the surface water resources of the basin are sufficient to meet the demands of the area, their occurrence and non availability of storage reservoir make it impossible to fully utilize this precious resource throughout the year. The precipitation usually occurs during monsoon months besides a winter rainfall and little snowfall also are other inputs.

For extrapolation to country level, two or three different types of basin (representing water surplus, and water deficit) should be selected for detailed study and then their results could be successfully extrapolated to other basins in the country. The smaller basins should be grouped into few larger basins to represent province and/or country level results for comparison with the extrapolated results.

CHAPTER 4

RECOMMENDATIONS

4.1 Applicability and Desirability of BHIWA Type Model to Pakistan

The water resources planning and management models such as Indus basin model have been used in Pakistan to formulate guidelines for meaningful dialogue and policy implications. The Indus Basin Model Revised (IBMR) is a basin-wide mathematical programming model, written in General Algebraic Modeling System (GAMS) language to assist in analyzing policies related to agriculture and irrigation development projects in the Indus River Basin.

A) Indus basin family of models

1. Indus Basin Model Revised – (IBMR-III), 1992
2. Indus Basin Model Revised (IBMR),1985-86
3. Indus Basin Standard Model (IBM), 1981-82
4. Farm Level Model (FLM), 1974-75

B) Capabilities of IBMR-III

1. Future projection of agriculture production under different resource availability.
2. Optimum distribution of available water resources between the canal commands particularly within the provinces.
3. Identification of resource limitations on desired crop production.
4. Evaluation of water resources projects particularly at the national level.
5. Groundwater balance calculations allowing for tubewell development.
6. Its zonal and network models can be used for the zonal projects.
7. The model can be used to study the impact of one or more projects on the overall Indus Basin System.

C) Application of IBMR Model

Water and Power Development Authority (WAPDA) applied IBMR model to following studies

1. Evaluation of Irrigation Benefits from Bhasha-Diamer Dam Project (2002)
2. Salinity Management Alternatives, studies under IIMI, Pakistan (1995-1998)
3. The Ranking Study of new Irrigation Projects as a result of Water Apportionment Accord (1991)
4. The Indus Basin Case Study of Complex River Basin Management in a changing global climate conducted by University of Colorado, USA
5. Water Sector Investment Planning Study (1989)

World Bank applied IBMR model to following studies

1. Raised Mangla Dam Project (1991)
2. Agriculture Impact Assessment Study of Kalabagh Dam Project (1985)
3. SCRAP Transition Pilot Project (1985)
4. Left Bank Outfall Drain Stage-I Project (1981)
5. On-Farm Water Management (1981)

D) Limitations of IBMR model

1. The model has incorporated 15 specific crops only.
2. The model assumes stress for wheat only. Stress for other crops need to be included.
3. Aquifer behaviour is taken into account, but based on a predefined depth to the water table.

4. The model does not simulate the irrigated area outside the Indus Basin.
5. The model does not simulate flood protection benefits.
6. Drainage component is not included directly.

4.2 Model Development Necessity

The use of models for water resources planning and policy maker provides a baseline for quick analysis and debate. It is an easy and efficient way to determine the needs and formulation of strategies to meet them and to evaluate their relative impacts on resources and environment. Also the water resources policy models like BHIWA, helps policy makers to test various alternative options and to see their impacts on resources in a scenario based approach. It would assist in optimization of solution. The use of model involves the following six steps for identifying the best option from many available choices.

Step 1	Identifying problems and opportunities
Step 2	Inventorying and forecasting conditions
Step 3	Formulating alternative scenarios
Step 4	Evaluating alternative scenarios
Step 5	Comparing alternative scenarios
Step 6	Selecting policies to reach acceptable scenarios

4.3 Possible Action Plan

The present Nari Basin study was carried out with the secondary data available. The calibration shows a good match with the observed values of river flows at the basin outlets, recharge to groundwater and water use in basin. The model required parameters to be verified with the data obtained from the field. A comprehensive study using the observed parameters as input in the model can be useful to generate various scenarios for basin management.

The Nari Basin is a groundwater deficit but the surface water resources, whose availability is a problem, are more than the requirements. Most of the rainfall occurs in monsoon period causing severe floods in the downstream kachhi plains.

Yet another basin study using the same approach as ICID's Country Policy Support Programme (CPSP) could be carried out for some larger basins of Pakistan, where the data is available and reliable. The study should include the field activities for collecting necessary input parameters which are very important for the calibration as well as for the purpose of future scenarios analysis.

4.4 Suggestions

The BHIWA model is a good tool for estimating the basin level water resources availability, need and the impact of future water resources development. It can be used successfully for a basin level study to test various future scenarios after proper calibration is achieved. Although the model uses numerous classes of land according to various land uses, it is not a 'distributed model'. The model does not predict the spatial variations in rainfall, potential ET, intensities of irrigation etc within the irrigation area and does not therefore allow the understanding of spatial variations in the hydrologic behaviour. The following links when added to BHIWA Model can make it a more comprehensive policy model.

1. To estimate the food demands and needs of the inhabitants of a basin, a separate module should be added in BHIWA model. This can also be done by linking IWMI's PODIUM model, which is a good tool for assessing the future food demands and projections with the BHIWA model.
2. ET is a most important parameter in the BHIWA model for the calculation of river flows. Presently, this parameter is estimated using a separate computer model like CROPWAT. Sometimes it may be difficult for the policy makers to use CROPWAT model. Therefore, climatic parameters can be added in the data sheet that could be used to calculate ET within the model. An option should be provided to use monthly, 10-daily, weekly or daily values.
3. The formulation of crop groups in the model is not very user friendly. A separate sheet dealing with land parcel module is available. Major crops data regarding crop coefficients, crop duration, root depths, crop growth- soil moisture relationship could be available in the model to be selected and edited/ modified accordingly.
4. Converting administrative and/or district level information into basin level information sometimes may not give desirable results. This is more likely where (a) the area of the administrative unit is not much smaller than that of the basin or sub-basin and (b) when the attributes like agricultural land, irrigated land etc. is highly non-uniform within the unit.

5. The model does not use growth rates for the purpose of future projections. The parameters for evaluating the future impacts of water resources needs and availability has to be determined externally in the current version of BHIWA model. The induction of growth rates rather than values could be a valuable addition.

6. Data entry process in the current version of BHIWA model is not user friendly; for each parameter user has to move to the data sheet in a particular cell or link. This can result in errors in data entry process. It would facilitate, if all the data parameters could be provided in a single sheet, that would be used for various calculations within the model, which will make data entry process much user friendly.

CHAPTER 5

CONCLUSIONS

The key conclusions emerged from the CPSP study-Pakistan are as follows:

1. ICID's BHIWA model for an integrated and comprehensive water assessment at basin level was widely appreciated during Basin and Natinoal Level Consultations. The model may need to be further upgraded to enable weekly working to suit the climatic settings of Pakistan.

2. Applicability of BHIWA model to larger size basins such as the main Indus basin in Pakistan was an important point of discussion in view of the need to develop and analyse country level scenarios for future development of the water resources aimed at food and environment security. A number of other models are also available and needed to be pooled to establish relative advantages for a specific purpose. It was noted such an exercise could be taken up in the next phase of CPSP, if feasible.

3. The model has reasonably succeeded in bringing out the current and future challenges in managing water resources of the selected Nari river basin for agriculture, flood control and domestic and industrial water use. The necessity of building additional storages was highlighted for multi purpose use namely to prevent mining of groundwater resources in the middle parts, to augment surface water irrigation supplies and to provide protection against flash floods in the lower parts and further down in the Kachhi plains. Afforestation / watershed management in upper reaches as a complementing strategy was also tested. In addition, expansion of horticulture crops and use of high efficiency methods of irrigation were acknowledged as the short-term goals to alleviate the problems of water scarcity.

4. The preliminary results of PODIUMSIM available from a separate study project show substantial food shortages in Business As Usual scenario for the country for year 2025. The potential for vertical growth (land productivity per unit of water) besides additional development of balance resources and high efficiency water use was cited as the major strategies to overcome constraint of water resources. In this context, there is an urgent need to organize promotional tours/ seminars for popularising use of drip and sprinkler methods in a big way, particularly in areas with saline groundwater. ICID's could assist PANCID in these efforts.

5. It was shown that of the present total water use of 132.8 billion cubic meters, about 92.6% are withdrawn for irrigated agriculture while domestic and industrial use is 5.4% and 2%, respectively. It was estimated that by 2025 total water requirement in Pakistan will be around 167 billion cubic meters i.e. about 35 billion cubic meters more than that of the present use. Development of additional water resources and adoption of water saving irrigation practices was therefore considered as necessary.

6. The national consultation noted the need for

analysing and modelling the surface and groundwater related problems in a better way. Such models, apart from quantifying the surface and groundwater balances and their interactions, need also to model the water quality, in particular the salinity. Thus, the overall salt balance, and the phenomena of soil salinity and groundwater salinity would also get modelled, and the impact of various management strategies, on these aspects, vital to Pakistan, could be studied.

7. The consultation ended with a positive note as to usefulness of limited activities under CPSP Phase I and the need to take forward such interactions in the future. More activities are envisaged to extend the experience of Nari basin to the main Indus system for formulating country level scenarios and testing various policy options.

ANNEXURES

ANNEXURE 1

COUNTRY POLICY SUPPORT PROGRAM

PAKISTAN NATIONAL CONSULTATION
30 JULY 2005, LAHORE, PAKISTAN

LIST OF PARTICIPANTS

INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (ICID)	
Name	**Designation**
Mr. M. Gopalakrishnan	Secretary General, ICID
Mr. A. D. Mohile	CPSP Study Team Leader
Mr. L. N. Gupta	CPSP Central Team Leader
Dr. S. A. Kulkarni	Director (I), ICID
PAKISTAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE (PANCID)	
Mr. I. B. Sheikh	Chairman, PANCID, Chief Engineering Advisor/ Chairman Federal Flood Commission (FFC)
Mr. M. Alamgir Khan	Superintendent Engineer, FFC Coordinator, ICID Affairs
Mr. Javaid Iqbal Bokhari	Deputy Engineering Advisor, FFC, Islamabad
NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LIMITED (NESPAK), LAHORE	
Mr. Abdul Rauf	Vice President, Water & Agriculture Division
Mr. Bashir Ahmed Qureshi	Vice President Water & Agriculture Division
Mr. M. P. Aftab	Vice President, Environment and Public Health Engineering Division
Mr. Nasiruddin	Study Team Leader
Mr. Farooq A. Qureshi	Hydraulic Design Expert
Mr. Asrar-ul-Haque Qureshi	Water Resources Management Expert
Mr. A. G. Randhawa	Agro-Economist
Mr. Bashir A. Sial	Drainage Expert
Ch. Abdul Latif	Agronomist

Mr. Abdul Samad Qureshi	Irrigation Engineer
Mr. Mukhtar Ahmad	Water Management Expert
Mr. Muhammad Saeed	Irrigation System Design Expert
Mr. Abdul Khaliq	Hydrologist
Mr. Rafaquat Ali	Hydraulic Engineer
Mr. M. Kaleem Ullah	Numerical Modeler
Mr. Shehzad Ahmed	Numerical Modeler
Mr. Abdur Rehman	Sociologist
BALOCHISTAN	
Mr. Abdus Salam Khan	Secretary, Irrigation & Power, Deptt., Govt. of Balochistan
Mr. Javed Muhammad Iqbal Awan	Secretary, Agriculture Deptt, Govt. of Balochistan.
Dr. Muhammad Saleem Sheerani	Secretary, Forest Deptt. Govt. of Balochistan
Mr. Arbab Muhammad Yousuf	Secretary, Public Health Engineering Deptt: Govt. of Balochistan
Mr. Abdul Karim	Additional Secretary (Agriculture.), Govt. of Balochistan
Mr. Naseem Bazai	Chief Engineer Irrigation (South), Irrigation & Power Deptt.
Mr. Ali Muhammad Shah	Superintendent Engineer. Sibbi Irrigation & Power Deptt.
Mr. Abdul Baqi	Superintendent Engineer, Loralai Irrigation & Power Deptt.
Mr. Iftikhar Mir	Executive Engineer Loralai, Irrigation & Power Deptt..
Mr. Muhammad Idris	Director (Water Management), Agriculture Research Institute, Quetta
Ch. Zulfiqar Ali	Director General,. National Watercourse Improvement Programme.
Dr. Abdullah	Pakistan Council of Research in Water Resources, Quetta
Mr. Mahmood A. Sulehri	Regional Manager, NESPAK
Mr. Muhammad Ayub	Senior Engineer, NESPAK
Mr. Kamran Babar	Director, Cameos Consultants
Mrs. Yasmin Ehsan	Technical Officer, Water and Sanitation Authority, Quetta
Mr. Amjad Rashid	Chief Executive, Taraqqi Foundation, Quetta
Maj (R) K. Safi Wasiuddin	Executive Director, Society Environmental Awareness, Quetta
Dr. Abdul Majeed	Head, Water Programme, IUCN Balochistan
Mr. Azam Kasi	Chief of Section (Water), Planning & Development Deptt:
Mr. Qamar Baloch	Director General, Planning & Development Deptt:
Mr. Asad	Cameos Consultants
OTHER FEDERAL GOVERNMENT/ ORGANIZATIONS AND INSTITUTES, LAHORE	
Mr. Mushtaq Ahmad Chaudhary	Member (Water), Water and Power Development Authority (WAPDA)
Mr. Waseem Ahmad	General Manager (Central) Water, WAPDA
Mr. Hasnain Afzal	Chief Engineer National Drainage Programme, WAPDA
Mr. Mushtaq Ahmad Gill	Director General Agriculture Punjab (On Farm Water Management)
Mr. Sajjad Naseem	Chief Engineer, Drainage & Flood, Punjab Irrigation Department

Syed Akhtar Hussain Shah	Principal, Government Engineering Academy Punjab
Mr. Ehsanullah Sardar	Head, Irrigation Research Institute
Dr. Muhammad Latif	Director, Centre of Excellence in Water Resources Engineering, University of Engineering and Technology Lahore.
Mr. Aslam Qureshi	Provincial Coordinator National Drainage Progamme Punjab
Mr. Sabir Ali Bhatti	Water Resources Expert
Mr. Hammad Naqi Khan	Director, Freshwater & Toxic Programme, World Wide Fund for Nature
Director	International Water Management Institute
Dr. Muhammad Ramzan Chaudhry	Acting Director General, International Water Logging and Salinity Research Institute
Dr. Mehboob Alam	Director (Drainage), International Water Logging and Salinity Research Institute
Mr. Muhammad Basharat	Jr. Engineer, International Water Logging and Salinity Research Institute
Mr. Abdul Rauf	Regional Director, Pakistan Council for Research in Water Resources
Ch. Muhammad Ashraf	Director Headquarters (Water Management), Agriculture Depett: Punjab
Mr. Aslam Rasheed	Water Resource Expert, World Bank Advisor
Mr. Mike C. Lin	Team Leader, Study for Releases below Kotri Barrage to Check Seawater Intrusion
Dr. Zaighum Habib	Water Resources Expert/Modeler
Mr. F.A. Zubari	Ground Water Expert
Dr. M. S. Shafique	Water Resources Expert
Dr. Abid Bodla	Member (Engineering), Planning & Development Board
Capt. (R) Arif Nadeem	Secretary, Irrigation & Power Deptt: Govt. of Punjab
Ch. Mazhar Ali	Advisor, Irrigation & Power Deptt: Deptt: Govt. of Punjab
Engr. Brig.(R) Khurshid Ghias Ahmad	Secretary General, Institute of Engineers Pakistan
Mr. Saeed Illahi	Senior Engineer, Associated Consulting Engineer ACE (Pvt) Limited, Lahore
Mr. Waseem Nazir	Regional Director, Mott. MacDonald Ltd.
Syed Raghib Abbas Shah	General Manager (Coordination & Monitoring), WAPDA
Prof. Syed Qasim Ali Shah	Professor, Govt. Engineering Academy, Punjab
Dr. Nadeem Asghar Gill	International Water Management Institute (IWMI), Lahore, Pakistan
Mr. Mujeeb Akhtar	International Water Management Institute (IWMI), Lahore, Pakistan

ANNEXURE 2
PAKISTAN NATIONAL WATER POLICY (DRAFT)

PREAMBLE

This Draft National Water Policy has been prepared as a part of the programme of Sector Policy Studies being financed under Phase-I of the National Drainage Programme. It has been prepared through extensive consultation with concerned stakeholders. The Draft National Water Policy presented herein includes changes made to the previous drafts as a result of the National Workshop on Water Policy which was held in Lahore in April 2002 at which 130 delegates from the Federal Departments/Agencies, Provincial Governments, NGOs, Farmer's representatives and resource management specialists participated and discussed the Draft. The revised draft has also taken into account the concepts being developed in the National Water Strategy, which is being formulated concurrently to ensure that the Policy and the Strategy are coherent.

Water is a precious and increasingly scarce natural resource in Pakistan and is literally the lifeline for survival, health and sustaining national economic development. Only a few decades ago, Pakistan was considered to have abundance of water. Now, as in many other areas of the world, population growth, economic development, rapid urbanization and industrialization, are applying added pressures on already limited resources of Pakistan and it is rapidly becoming a country of water scarcity. The growing imbalance between water supply and demand has led to shortages, unhealthy competition, and conflicts between shareholders, rising pollution and other environmental hazards. Water shortage is also a key hurdle in continued economic development of Pakistan. Hence, there is an urgent need to address this matter in a forthright, comprehensive and effective manner.

A rational approach has to aim at a realistic balance between developing new resources and efficiently managing the existing supplies. The options for developing new resources, through additional storages, have been controversial and require an in-depth analysis as a part of an integrated approach. Although, there is great scope for managing (curtailing) demand, yet this also requires strong political will and determined efforts including strengthening of institutional capacity and some radical changes.

Pakistan's agriculture depends heavily on artificial (man-made) irrigation, with 90 percent of its agricultural output originating from irrigated areas. Irrigation has, therefore, received relatively higher priority over the preceding several decades but despite this there remain serious shortfalls in terms of quantity as well as quality. Attention is also called for in the field of urban and rural domestic water supplies, industrial supplies, hydropower development, drainage, flood control and environment-related matters.

Irrigation and agriculture are both provincial responsibilities. The Indus Basin water resources belong to and are shared by all the Provinces and the Federally administered areas of the country. The Federal Government indeed has the overall responsibility of monitoring and to efficiently conserve, develop and manage the water resources for the use and benefit of the Nation. The Federal Government is also to ensure that the water allocated to the Provinces is equitably distributed and delivered to them.

The Federal Government has, therefore, taken a lead in developing a National Water Policy and a strategy for effective regulation, development and management of the entire water sector across the country, in partnership with all stakeholders, including the Provincial Governments.

In the formulation of National Water Policy, the following were the essential requirements: Review & in-depth analyses of national water resources, their temporal and spatial distribution/variations.

Future water vision - 2025.

- Review of historic performance including success and failure of past strategies. Consultation with stakeholders.
- Review of international context of water policies and agreements.

These analytical frameworks provided the necessary input regarding the availability of resources, constraints in optimal development and a way forward for addressing the issues and for focusing on remedial approaches. Once the Policy has been framed, a roadmap for its implementation in the form of a Strategy is to be finalized. Some of the components of the Strategy would be an investment plan which outlines the financial considerations, capacity building to plan and manage water resources, institutional and human resource issues, development of an adequate information system, participation of stakeholders, and consideration of environmental aspects of water-resource management etc.

Based upon review of various plans prepared and approved by the Government in the recent past, the following paragraph would aptly summarize the National Water Vision which forms the foundation of the National Water Policy:

"By 2025, Pakistan should have adequate water available, through proper **conservation and development. Water supplies should be of good quality, equitably distributed and meet the needs of all users through an efficient** management, institutional and legal system that would ensure sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resources, ability to pay and participation of all stakeholders".

The National Water Policy presented herein has a target year of 2025, as stated in the Vision Statement. Although the Policy is intended to have a long-term validity, yet it should be subject to review and updating, based upon experience, preferably on a five yearly basis.

The detailed analysis of the current situation, issues and projections are contained in three Supporting Volumes as follows:

Volume I : Analysis of Key Issues

Volume II : Water Resources of Pakistan - Availability and Requirement

Volume III : Legal Aspects

1. INTEGRATED PLANNING AND DEVELOPMENT OF WATER RESOURCES

Issues

Irrigated agriculture uses over 90% of the available water resources, feeds the nation, provides the majority of rural employment and drives the economy through the supply of raw materials to industry, and is the source of major portion of export earnings. The anticipated population increase of Pakistan, from 141 million currently to 221 million by 2025, will place increasing pressures on the already scarce water resources. The significantly increased demand for agricultural products that the population increase and rising wealth will result in, will require a large increase in water availability to feed the nation and drive economic development. This requirement will be compounded by non-agricultural uses (domestic, industrial and environmental) gradually taking an increasing share of the available flow. Contrary to this scenario, the actual water availability in critical months is declining, as a result of sedimentation of the existing reservoirs.

Water utilisation in all sectors is inefficient and conservation and demand management can, and must, play a critical role in improving water availability. However, conservation alone cannot **meet the anticipated** levels of demand. More water must be made available in the critical months of the year and this can only be achieved from increased storage of water through the construction of new dams and reservoirs. This has environmental consequences, but these can and should be mitigated. Further reinforcement of the integrated approach to planning, development and management of water resources is required to ensure availability of water to all sections of the society on an equitable and sustainable basis for the present as well as for future generations. This has to be done in a cost-effective and environmentally friendly manner considering water as an economic and social resource.

Integrated planning for the entire water sector is also necessary because to avoid duplication and wasted effort. For instance, over the preceding decades the need for development of navigation through our Pakistan huge network of rivers, inter-river links and canals, has kept on emerging again and again, even though the issue stands settled about its infeasibility.

There are many areas and pressing issues such as deteriorating groundwater and soils, imbalance in groundwater extraction and recharge, contamination of rivers and streams, inequitable distribution of water, etc. which require an integrated basin-wide approach, rather than fragmented institutional activities which leads to wasteful duplication and inefficient utilization of resources.

Policy

In order to undertake basin-wide planning and coordinated development of water resources in the country, there is need to:

1.1 Adopt the principles of Integrated and Unified River Basin Development to ensure that all aspects of water are properly taken care of in decision-making for water resources development.

1.2 Prepare Water Resource Plans for development:

- In co-ordination with the policies and projects of other sectors, both public and private;
- In accordance with Planning and Regulatory Zones; and
- In accordance with Manuals of Good Practice.

1.3 Ensure that water resource plans include sufficient attention to both conservation and enhanced efficiency of water utilization in all sectors.

1.4 Ensure that water-resource plans take a balanced approach to development across all sectoral uses and that water supplies are equitable and **sustainable and that existing** water rights are protected. Ensure that surface and groundwater resources are developed and utilized sustainably and conjunctively and **that water** is considered as an economic and social resource.

1.5 Prepare and adopt conservation and demand management strategies, including public awareness programmes, to reduce water requirements (without compromising productivity) across all sectors..

1.6 Ensure that water resource plans are developed that will increase the storage capacity through the development of new reservoirs in and outside the Indus Basin, to realize the vision of ensuring availability of sufficient water for all sectors up to and beyond 2025, particularly during critical months of the year. Ensure that the environmental consequences of this are determined and mitigated. Pakistan's irrigation network development has now reached a mature stage where the concept of carryover storages, being used world-wide, needs to be seriously considered to overcome drought years.

1.7 Ensure that in water resources planning, water quality is given as much importance as quantity

1.8 Do not consider developing navigation, in the rivers, inter-river links and canal system, since it is neither technically nor economically feasible, except in the lower reaches of the Main Indus.

1.9 Promote delineation of the following Zones by the Provincial agencies to ensure that within each Zone the development of water is planned effectively:

- Water Resources Planning Zones in areas where competition for limited water is high;
- Flood Risk Planning and Regulatory Zones in flood prone areas.
- Fresh and Saline Groundwater Zones.
- Groundwater Management Planning and Regulatory Zones in areas where the water table needs to be effectively managed.
- Drought Prone Planning Zones to ensure that adequate plans are in place when and where droughts occur.
- Watershed Management Zones in upland areas.
- Environmental Management Zones in areas of environmental hazard.

1.10 Assess and monitor the impacts of climate change on water resources development and account for these impacts in future water development strategies.

1.11 Undertake Initial Environmental Evaluation Studies (ZEES) and/or Environmental Impact Assessments (EIA) for all water sector development projects, whichever is appropriate.

1.12 Undertake, encourage and support research and development of improved water management **strategies** for increasing efficiency, productivity and judicious use of available resources.

2. IRRIGATED AGRICULTURE

Issues

Irrigated agriculture is by far the largest sector/user of water and is also the prime mover of the economy. To meet the food and fiber requirements of the growing population and to ensure sustained economic development (including exports) through to year 2025, there is need to increase agricultural output significantly. This will require yields to be raised as well as the cropping intensity and the area under irrigation. The latter two categories will require additional water which will have to be found through enhanced efficiency and conservation as well as through increased storage and better groundwater management. Rainfall is another potential source of water. Rainfall harvesting and other techniques can be used in hill torrents areas for irrigated agriculture.

Assuming a 50% increase in crop yields attributable to better farm practices, efficiencies and other on-water inputs, there still remains a gap between the projected year 2025 food production and the food requirements. Water input of 28 MAF at farm gate would be necessary. Of the 23 MAF of estimated surplus river-flows available for canal diversions (13 MAF reaching the farm gate), a supplemental storage capacity of 18 MAF would be required, otherwise the 70 to 100 days availability of flood flows would be of little consequence in terms of crop raising.

Another problem is inadequate maintenance of the irrigation infrastructure that is partly due to insufficient funds, and is causing deterioration of the system. Other factors that reflect on.22 unsystematic maintenance are forcing over-delivery of supplies in canals to meet increased demands, major increase in the unauthorized use of canal banks as roads, financial indiscipline, and declining moral values. The costs of supplying irrigation water and drainage, especially the O&M costs, should be recoverable and the system made financially self-sustaining, whilst recognizing that this can only be achieved with farmers receiving sufficient returns from agriculture.

Barring recent drought years which have caused a temporary lowering down of the water table, inadequate drainage facilities have resulted in 18% of the irrigated land having been waterlogged and about 5% suffering from severe salinity. Improved irrigation efficiency and better drainage facilities are required to mitigate this.

Policy

Towards this end, there is a need to:

2.1 Ensure that sufficient food is produced to meet Pakistan's growing food requirements and food security.

2.2 Improve the productivity per unit of water. This should be the primary goal in irrigated agriculture. High delta crops and canal irrigation of marginal areas, should be discouraged.

2.3 Target production of higher value export crops such as "Basmati" rice, cotton, fruits, vegetables, etc., without sacrificing the wheat crop.

2.4 Target the vertical expansion of agriculture over horizontal expansion, in view of its lower costs.

2.5 Promote and **support higher** efficiencies in conveyance of irrigation water, prioritize farmer education, encourage recycling, equitable delivery and reuse of water and other demand management techniques.

2.6 Ensure sustainability of irrigation infrastructure through (a) awareness of farmers and government service delivery personnel, (b) increasing the level of cost sharing and (c) increasing community and farmer participation in the management decisions related to infrastructure.

2.7 Enforce high maintenance standards for irrigation infrastructure to avoid system deterioration. Higher level of funding is required during initial years to take care of accumulated/deferred maintenance.

2.8 Ensure more equity in water distribution, with particular emphasis on tail-end farmers, by supporting and strengthening farmers' organizations.

2.9 Encourage and support development of additional storages to meet demand-based needs of crops.

2.10 Promote the transfer of management of irrigation schemes to AWBs and FOs, with prior infrastructure rehabilitation, and establishment of independent regulators to ensure equitable water distribution while facilitating conflict resolution. Promote empowerment of FOs to collect O&M charges and to impose fines for non-payment.

2.11 Promote and support improved marketing of agricultural products in order that farmers achieve higher incomes.

2.12 Encourage and support harnessing of hill torrents for enhancing agricultural production and to reduce floods.

2.13 Reduce waterlogging and salinity though improved water management practices and irrigation efficiencies, explore alternatives to such practices as the "puncho" irrigation system. Promote lining of channels in saline groundwater areas and improve drainage of waterlogged lands.

2.14 Develop farmer education programmes to improve water use efficiency.

2.15 Encourage farmers to grow low delta crops with higher economic returns.

2.16 Promote private investment in small irrigation and drainage schemes.

2.17 Promote and support research and development of water conservation techniques and improved irrigation methodologies.

3. MUNICIPAL, RURAL WATER SUPPLY AND SANITATION

Issues

Approximately 60% of the current population has access to municipal water supply (85% in urban and 55% in rural areas). Infrastructure for wastewater disposal in the shape of proper sewerage networks is lacking and the few sewage treatment facilities where they exist, are largely non-operational. The quality of water supplied at the consumer point is poor as a result of contamination in the leaky distribution networks. Contamination becomes particularly acute when water supply in the distribution network is based on rotation to "manage" shortages or is shutdown for other reasons such as failure of power supply to tube wells. The shortages and poor quality of water supply contributes significantly to the high infant mortality rate and child sickness. A lack of operational sewage treatment facilities further pollutes water bodies, and the direct effluent disposal causes hazardous conditions in many streams and rivers. High priority needs to be **accorded in making** an adequate investment in this sector.

In terms of quantities, domestic water needs (besides industry), will pose rising competition to the traditional irrigated agriculture sector. Overall objective is to provide potable and safe water and sanitation to most people by 2025, which is essential to safeguard and improve public health and people's earning capacity.

Policy

Towards this end, there is a need to:

3.1 Prioritize sectoral water rights in sharing national water resources, for drinking, industry and agriculture, in that order.

3.2 Facilitate the provision of clean potable water supply to the population through appropriate and affordable delivery systems by 2025.

3.3 Promote investment through public - private partnerships in urban water supply.

3.4 Target achievement of full financial sustainability in urban water supply development. Charging system should ensure appropriate subsidies to poorer communities.

3.5 Charge Rural water supply and sanitation services at affordable rates.

3.6 Provide hygienic sanitation facilities for 80% of the urban population by 2025 through the provision of appropriate waterborne sewerage systems and wastewater treatment.

3.7 Provide 50% of the rural population with sanitation by 2025.

3.8 Promote effective rehabilitation and efficiency improvements in existing water supply systems, through justifiable investments, significant reductions in non-revenue water, increased water metering and other initiatives.

3.9 Improve the quality of general-purpose domestic water in urban and rural environments and ensure water of satisfactory quality for all.

3.10 Preserve and protect surface and groundwater resources which offer sustainable sources of supply for local communities in both urban and rural areas.

3.11 Encourage and support rainfall harvesting schemes for augmenting municipal water supply.

4. WATER FOR INDUSTRY

Issues

Industry currently uses only 2% of the total water consumption, but this is expected to rise to three times by 2025. Most industrial water is derived from privately owned wells, although a substantial amount is also taken from the canal system. Industrial effluent is mostly discharged untreated into natural watercourses, despite the existence of laws to the contrary. Chemicals and toxic elements thus find their way to otherwise freshwater bodies polluting these in many areas.

Policy

It is, therefore, necessary to:

4.1 Make available and reserve sufficient supplies of water for industry on priority basis to promote industrial development and economic growth.

4.2 Undertake a study enabling enactment of legislation to formally allow and define the use of water abstraction licenses and water rates for industrial use.

4.3 Encourage industries to treat wastewater on-site to remove toxic chemicals and other pollutants according to the new improved standards and legislation and the polluter pays principle.

4.4 Promote industrial expansion on larger industrial estates to simplify waste water treatment and monitoring of effluent disposal.

4.5 Enforce effective implementation of effluent disposal standards.

4.6 Promote community participation to check water pollution.

5. WATER FOR HYDROPOWER

Issues

Whilst there is sufficient power generation available to meet the anticipated needs up to 2005, additional capacity is required to meet the demand further beyond. Pakistan's large natural gas reserves are planned to meet much of the increased demand even though there is a current shortage of gas supply to powerhouses of WAPDA.

The present ratio of hydropower to thermal power generation is 28:72, which is almost the reverse of our historic optimum of 70:30. Therefore, additional hydropower capacity should be developed, preferably, in conjunction with new storage reservoirs. Hydropower is the cheapest and environmentally the cleanest way of generating electricity. It is also a renewable source since the prime driving force is continually replenished by nature's hydrologic cycle. Environmental issues, including resettlement are, of course major concerns, which need to be appropriately addressed. The development of run-of the-river hydropower schemes in the North of the country is very attractive and commercially viable and hence should be undertaken through the private sector, although an enabling environment will need to be developed to promote this.

Policy

To achieve these objectives, it is required to:

5.1 Recognize the nation's hydropower facilities as a major 'natural resource' and a key component in the development of the industrial, agricultural and service sectors throughout the country, and in raising living standards in urban as well as rural areas.

5.2 Optimize the use of existing hydropower generating capacity in a manner which is sustainable and also compatible with meeting the national irrigation requirements.

5.3 Undertake and promote further development of hydropower resources in a manner which is technically sound, economically justified, and socially acceptable.

5.4 Adequately compensate and properly resettle the displaced population.

5.5 Differentiate between large (with major storage) and small (with insignificant storage) hydropower schemes to facilitate and to enhance the ability of the private sector to invest in the latter hydropower category.

5.6 Encourage the development of hydropower potential, specially, in the small run-of-the river schemes as outlined in the 1998 "Policy for New Private Independent Power Projects". Also, contribute to research and development of small-scale, low-head hydropower technology leading to various categories of off-the-shelf standardized equipment.

5.7 Share the O&M costs of new storage dams between the hydropower sector and other benefiting sectors including the agriculture sector through AWBs, industry and urban consumers.

5.8 Mitigate the effects of implementation of the above policies on the environment.

5.9 Build the capacity of the existing hydro authorities, including the national Electric Power Regulating Authority and the Private Power and Infrastructure Board to encourage public/private partnerships to enhance hydropower development.

6. WATER RIGHTS AND ALLOCATIONS

Issues

Whereas water rights between the provinces are well-defined under the Water Accord of 1991, yet controversies as to its interpretation and implementation do emerge, specially with regard to (1) construction of new storage reservoirs and (2) sharing of shortfalls during the periods of low water availabilities.

Within the irrigated agriculture sector, water rights are again well defined, but do not promote efficiency nor do they take into account the economic value of water. Moreover, the system is not designed to allow users to know whether they are getting their due allocation.

Significant proportions of the population do not have access to safe drinking water. The water requirements for cities will significantly increase and increasing allowances will have to be made for this.

Recognizing the fact that during acute water crises, no amount of organizational improvements, or mechanisms can eliminate the basic cause of water shortages, the underlying problem has to be solved rather than managing it.

Policy

Towards this end, it is necessary to:

6.1 Ensure that all citizens have an equitable right of access to clean water and sanitation facilities.

6.2 Ensure the water rights of the provinces in accordance with the 1991 Water Accord in full.

6.3 Improve the functioning of IRSA, in order to improve the environment and to inculcate an atmosphere of greater harmony and mutual cooperation in meeting the water allocations.

6.4 Expand the installation of an automatic hydro telemetric network so that inflows, outflows, canal withdrawals and water levels at all critical points of the Indus Rivers System, are available to all the provinces and the concerned federal agencies at all times, for reasons of transparency of operation, and to create an environment of mutual understanding and trust.

6.5 Harness and develop more water-resources in economically and socially desirable ways to eliminate/minimize water shortages, particularly during the critical crop-demand periods.

6.6 Initiate and facilitate an agreement among provinces on safe disposal of surplus drainage effluent, that is, a Drainage Accord similar to the Water Accord.

6.7 Establish mechanism for conflict resolution of water issues at various levels.

6.8 Create an enabling environment to permit water exchange, which enhances water use efficiency.

6.9 Promote the extension of mandate of AWBs to include water allocation and other issues of potable, industrial and environmental water supplies and water for the environment.

7. ECONOMIC AND FINANCIAL MANAGEMENT

Issues

Water is generally not perceived as an economic good and, therefore, revenue recovery from the users covers only a small proportion of costs, resulting in both a drain on government's finances as well as a deterioration in service. There is a need both to improve cost recovery and to raise the standard of system maintenance and supply in all water sectors. Furthermore, the undervalued water has traditionally been overused and abused. There is dire need of educating the public of the real value of water to make the users more conscious about it. This would help in somewhat reducing demand, would encourage efficiency of usage, and reduce pressures for unnecessary expansion in certain areas.

Policy

To achieve the foregoing objectives and to address the issues there is need to:

7.1 Emphasize the social and economic value of water.

7.2 Endorse the concept of realistic pricing of water in all sub sectors, not necessarily for full recovery, considering users ability to pay but to impart realistic information for users' awareness taking into account users ability to pay.

7.3 Promote appropriate charging systems to ensure collection of O&M costs and an increasing portion of the capital costs.

7.4 Promote the principle of full cost recovery in providing municipal water supply and sewerage services in urban areas to ensure that the responsible operating agencies are financially viable and are able to provide an efficient service. Billing mechanism has to ensure appropriate concessions to deprived communities, but this must be done in a fully transparent manner.

7.5 Encourage water metering and effective control over wastage of municipal water.

7.6 In the case of industrial wastewater, follow the principle "polluter pays".

7.7 Encourage and involve community organizations to prescribe irrigation charges and to become responsible for collection and imposition of appropriate penalties for non payment.

7.8 Introduce appropriate financial incentives to encourage water re-use, conservation, efficient use of water and to discourage over-exploitation and pollution.

7.9 Ensure that rural potable water supply and sanitation services levy charges that cover operating and maintenance costs.

8. GROUNDWATER

Issues

The importance of groundwater in Pakistan can be appreciated from the fact that quantitatively it is adding to the tune of in 80% of canals, water supplies are supplemented by groundwater. The gradual development of groundwater has been the primary instrument in increasing cropping intensity from 80% to 130% in the last four decades. Groundwater of acceptable quality has the potential to provide flexibility of supply in canal command areas, as well as extend irrigation to barani areas. If conjunctive surface and ground water use can be properly managed, there is the potential for further groundwater development while carefully controlling environmental and water quality aspects.

The quality of the groundwater in the Indus Plain varies widely. Areas subject to heavier rainfall and consequently greater recharge, in the upper parts of the Indus Plain, are underlain to great depths.27 with good quality waters of low salt content. Similarly, groundwater recharge occurring along the main rivers over geologic times has resulted in the development of wide and deep localized belts of relatively fresh groundwater. The over-mineralization of the groundwater generally increases away from the rivers and also with depth. In the **central parts of** the "doabs" in the Punjab, pockets of highly mineralized and unusable groundwater have developed containing from 4,000 to 20,000 PPM of dissolved salts. In the lower part of the Indus Plains, the area of relatively fresh groundwater is confined to a narrow strip primarily along the left bank of the Indus River.

With the dramatic increase in the intensity of groundwater exploitation, the major policy approach has changed from development of groundwater to its management. The main policy issues now relate to environmental sustainability and long-term availability. In real terms this means stopping and reversing the declining groundwater levels found in some regions, and reducing and eliminating the pollution of fresh groundwater aquifers due to lateral and/or vertical intrusion of saline water. Two different and partially opposing policy themes dominate the current management strategy. The first theme is the lowering of otherwise high groundwater levels through extraction of more groundwater, while the second theme is to check the lowering of water levels in the low recharge areas by reducing groundwater extraction for sustainability of agriculture.

Policy

In order to address these issues, there is need to:

8.1 Develop a groundwater regulatory framework to control and optimize groundwater exploitation.

8.2 Expedite transition of SCARP tube wells in the public sector to the private sector, and leave development of fresh groundwater entirely to the private sector.

8.3 Strengthen monitoring efforts to determine the sustainable groundwater potential and prepare groundwater budgets for Sub-basins and Canal Commands, and to check lateral/vertical movement of saline water interface.

8.4 Promote groundwater recharge wherever technically and economically feasible.

8.5 Evaluate various technologies being used for undisturbed extraction and skimming of fresh groundwater layers overlying saline water, and attempt development of improved techniques.

8.6 Evaluate all sources of recharge/discharge and their interaction on groundwater reservoir.

8.7 Encourage optimal groundwater pumping in waterlogged areas to lower water table.

8.8 Delineate areas with falling water table for restricting uncontrolled abstraction.

8.9 Encourage the Provinces to prepare a Groundwater Atlas for each Canal Command and Sub-basin. The Atlas should delineate:

- Groundwater development potential.
- Water quality zones.
- Water table depth zones.
- Recommendations for installation of different types of tubewells.

9. STAKEHOLDER PARTICIPATION

Issues

The conservation and extension of water resources of Pakistan is undertaken basically for the people of Pakistan to support their health, economic and social development. The operational management has been historically the responsibility of governmental organizations. Due to system inefficiencies, indifferent attitude of managers and condemnation of unilateral actions of governmental functionaries by users, it has lately been accepted to enhance the participation of all water stakeholders, namely those with an active involvement in water use such as farmers and rural communities as well as those who rely on water services for their health and livelihoods.

Stronger linkages are, therefore, required between the system operators and the beneficiaries. This will instil greater confidence of farmers as they participate in the O&M activities and introduce improved management. Improved equity in water distribution will be another benefit. There have been and will be difficulties in developing functional farmers' organizations to manage the irrigation and drainage networks. However, the process should continue to be promoted, and their contribution will gradually evolve, though government is likely to remain the major partner.

To effectively participate at all levels; the public must be aware of and have a fuller understanding of the issues in the water sector as well as their rights and responsibilities. It is the responsibility of the federal and provincial governments to ensure that the level of public awareness is raised. Change is always difficult (even though it may ultimately be rewarding), particularly because the participatory approval calls for a new type of relationship between the farmers and the government.

Policy

To achieve the policy objectives, there is need to:

9.1 Create an enabling environment for active stakeholder consultation and participation at all levels and in all aspects of the water sector including irrigation, drainage, rural water supply and flood protection, and drought activities.

9.2 Focus initially on water user's involvement in (1) water distribution to ensure that water reaches all members as per their due share; (2) adequate maintenance; (3) proper assessment and collection of water charges; (4) monitoring water and soil quality and (5) resolution of local disputes among members.

9.3 Promote, support and ensure that participatory programmes are effectively coordinated with policies and programmes of all other public and private bodies to encourage partnership and to avoid conflict.

9.4 Consider various approaches to transition. The most optimum appears to be the current pilot approach with continuous monitoring and critical analysis of problems encountered and remedies applied. Thereafter, serious consideration be given to fully adopting the participatory system in improved form (based on pilot experience) at all levels, horizontally as well as vertically.

9.5 Evolve public awareness programmes to highlight the objectives, namely, that farmers could receive more secure deliveries, government agencies would experience cost savings and the government staff would be re-allocated to new assignments both within the government and with the new water-user organizations.

9.6 Develop and implement a strategy to engage private sector participation in all aspects of the water sector.

9.7 Promote modern water resources management and its emphasis on community and individual confidence and participation in the performance, operation and ownership of water assets.

10. FLOOD MANAGEMENT

Issues

Floods have caused massive damage to infrastructure and crops in Pakistan, besides loss of life.

Monetary losses during the major floods since 1950 aggregate over ten billion dollars. Major floods during the years 1955, 1973, 1976, 1978, 1988, 1992, and 1995 resulted in inundation of millions of acres of land in various parts of Pakistan which constituted one of the most serious environmental hazards. Over 8,000 people lost their lives during these floods. Floods are detrimental not only in financial terms, but also in their ability to severely undermine the productive system, which needs to be free from uncertainties and frequent disruptions.

It is generally recognized that complete prevention of floods is almost a physical impossibility. **However, flood protection** to the extent it is technically and economically feasible, is a socio-economic necessity. By proper planning, means can be devised not only to minimize flood losses but also to conserve the surplus flows for augmenting water availability for productive use of the community. The recent drought, prolonged as it has been, must not be understood as meaning that Pakistan will not be hit by severe floods again. Indeed, the progressively declining storage, if not replaced, will eventually **mean that flood peaks on Indus and** Jhelum will be even higher due to loss of attenuation ability of the reservoirs.

In order to safeguard the Indus Valley and other flood prone areas from inundation, 5,822 Km (3,600 miles) of embankments have been constructed along major rivers and their tributaries in Pakistan. To protect embankments, to channelize flows through barrages and bridges, and to save lands and areas from erosion, 577 spurs have so far been constructed.

The nature and need of flood protection facilities vary according to specific physiographic characteristics and local conditions in different parts of Pakistan. In Punjab Province, the problems of inundation and land erosion are both prevalent. In Sindh, the river bed is generally higher than the adjoining lands and the river slopes are milder due to which the problem of inundation is far more serious. This is why almost throughout in Sindh, a double line of flood protection embankments has been constructed along both the banks of Indus. Wherever river current is anticipated to attack the embankments, heavy stone pitching and aprons have been provided as protective measures. In NWFP and Balochistan, besides river flooding, hill torrents create havocs due to their steep slopes which result in flashy sudden flows of high-magnitudes. In these areas, flood abatement/dispersion structures and retaining walls have been constructed covering parts of the area.

Despite huge investment made in this sector, breaches in embankments and failure of structures frequently take place causing heavy loss of life and property. As the impact of such damages is progressively becoming more intense with higher levels of development and economic activities, there is a need to review the existing design and maintenance standards. The latter is particularly in a deficient state, and a lack of budgetary funds is given as the main reason. In the case of Indus and Jhelum, where some flexibility is available in the form of flood control because of Tarbela and Mangla Reservoirs, a prudent operation can optimize flood benefits without significantly sacrificing the water and power benefits.

In Pakistan both structural and non-structural measures have been used to mitigate flood losses.

Principal non-structural measures include flood forecasting and warning, permanent relocation of people, flood insurance and land-use regulations. Under FPSPI, considerable work has been done in the field of non-structural measures including flood plain mapping of some major river reaches. However, there is lot of room for carrying out more work in this field.

Although considerable strengthening of flood forecasting work in the form of additional weather radar and telemetric system, has be done, still greater emphasis is required on accurately forecasting precipitation in catchment areas, and on the development of an early warning system.

Policy

In order to effectively address flood problems in Pakistan, there is need to:

10.1 Continue with the construction of additional flood protection facilities, but the planning of the flood protection works, zoning etc. for each reach of the river needs to be developed following an integrated approach for the entire reach. Moreover, greater emphasis needs to be laid on proper maintenance of the existing infrastructure.

10.2 Review the design and maintenance standards of existing flood protection structures, and make improvement where necessary to bring them to the level of functional capability and reliability.

10.3 Establish and promote flood zoning and enforce appropriate land use by avoiding growth of vulnerable developments in flood-hazard areas. Adjust land use, where feasible, to ensure compatibility with the frequency and duration of flooding.

10.4 Optimize reservoir operational rules to ensure efficient and prudent decisions to control floods, particular when the reservoirs are near full.

10.5 Improve and update the Flood Manual on a periodic basis making use of experience of successes and failures of the system. Include in the Flood Manual appropriate tables of names of villages/towns likely to be inundated by various flood magnitudes so that a system of timely warnings through radio and other means, can be launched to save life.

10.6 Make effective use of non-structural measures like flood forecasting and early warning systems to minimize flood losses through better forecasts. Promote and support research in to the better understanding of the monsoon systems causing Pakistan's high-magnitude floods, including travel of weather systems from Bay of Bengal, and their interaction with Westerly currents from Arabian Sea and from Mediterranean vis-a- seasonal low over Balochistan, Tibet Pleatu pressures, wind velocities and other relevant factors.

10.7 Create a flood response plan and ensure that the public is fully aware of the plan. In flood warning, factors of major importance are (1) level of awareness; (2) flood warning time and (3) reliability of warning and of the warning organization.

11. DROUGHT MANAGEMENT

Issues

Drought is a natural phenomenon that results from a prolonged absence or reduction in precipitation. Droughts are frequent events the world over, specifically in arid and semiarid regions of the globe in which a major part of Pakistan is located. Irrigated agriculture, which is practiced on more than 80 percent of cultivated areas of Pakistan, has largely provided a substitute to direct rainfall on cultivated land. However, large areas are affected by drought conditions when river supplies are adversely affected by reduced rainfall in the catchment areas. In non-irrigated areas, droughts are particularly devastating such as in Balochistan, Thar Desert, Thatta and Dadu districts in Sindh, and Cholistan Desert, Bahawalpur and Rahim Yar Khan Districts in Punjab.

Currently, seasonal forecasts based on statistical/ historical trends and AI Nino phenomenon, are made by the Meteorological Department, however, such forecasts are vague and they hardly come close to accuracy.

Response to emerging drought conditions and management of water resources under those conditions are poorly developed in Pakistan. A drought management plan (DMP) is an essential tool for government to ensure that appropriate institutional and legal structures are in place prior to the onset of drought conditions and that the necessary action is well-thought out in advance. DMP has to be tailored to the specific requirements of a river basin. For Pakistan two types of DMPs would be required separately; one each for Indus River Basin and the Hill Torrent Basins. Plans also need to take into account climate change, which may mean an increasing prevalence of droughts.

Policy

To improve the situation under drought conditions, there is need to:

11.1 Encourage development and dissemination of water conservation technologies for rainfall harvesting in non-irrigated areas.

11.2 Plan and expedite measures to carry surplus river flows through diversion and other structures to drought-prone areas.

11.3 Consider seriously the need for construction of carryover storages which is the only effective way of overcoming drought year(s).

11.4 Encourage and support Meteorological and other Departments/Agencies in carrying out research work in reliably predicting droughts (in terms of several months or even a year ahead) so that feasible counter-measures can be timely taken through modified releases from reservoirs and other water management strategies. Research should aim at developing appropriate mathematical models.

11.5 Encourage and support provinces to prepare Drought Management Plans (DMPs) for different drought prone areas.

12. DRAINAGE AND RECLAMATION

Issues

Water logging and salinity and the build up of salt in the irrigated lands of the country are perhaps the main environmental issues affecting the country. The development of measures to conserve water and thus reduce the amount of salt being applied to the land, and to provide adequate drainage and disposal of saline effluent are of critical importance.

Over the preceding decades, a major impact has been made by implementing drainage and reclamation measures to lower water table to optimum level and to achieve full benefits of irrigated agriculture. Over 70 Salinity Control and Reclamation Projects (SCARP) were prepared and implemented at a cost of $ 3.5 billion in the Indus Basin in the last 4 decades. These measures have been very effective in lowering the water levels and in minimizing salinity in the affected areas. Encouraged by the performance of reclamation measures undertaken by the government(s), over 600,000 private tube wells have been installed which are pumping about 50 MAF of groundwater. SCARP tube wells are being progressively transitioned to private sector. This is perhaps one of the biggest drainage and irrigation interventions through the participation of stakeholders. This joint public and private effort has to continue to further mitigate and completely eradicate waterlogging and salinity from the country. The successful technologies already tried and proven in the Indus Basin need to be appropriately expanded in addressing the problem further. Causative factors responsible for persistent waterlogging and salinity require further studies for formulating future plans. Waterlogged areas requiring immediate attention have to be appropriately delineated and prioritized.

Saline effluent has to be disposed of properly to safe areas or to the sea while safeguarding surface reservoirs, other freshwater bodies as well as groundwater from contamination. Through improved irrigation efficiency, the quantum of saline drainage effluent requiring disposal can be minimized to avoid the construction of high-capacity carrier drains.

Even normal canal water (500 ppm salt content) adds more than two (2) tons of salts per acre annually. Although a large part of this salt gets leached down, yet there is a need to study the salt balance of the system, particularly because marginal and even saline groundwater is being used for irrigation which is the source of a more serious problem of sodicity (secondary salinization). This phenomenon is adversely affecting lands in areas even where groundwater table is otherwise quite low. Once sodicity gets hold of the soil, remedial action is far more costly and difficult to implement.

Policy

To achieve the foregoing objectives, there is need to:

12.1 Make efforts to improve irrigation efficiencies and reuse or recycle drainage effluent in areas where it is generated, as far as possible to minimize drainage effluent.

12.2 Finalize Master Plan for Drainage, particularly taking into account efficacy of the past drainage efforts.

12.3 Expedite feasibility studies for the disposal of saline effluent including a study of the National Surface Drainage System (NSDS) based upon an evaluation of drainable surplus for each Province and each Canal Command System.

12.4 Reach an Inter-Provincial Drainage Accord to manage the disposal of saline effluent and transfer unavoidable saline effluent to safe areas or the sea.

12.5 Explore and encourage, the use of bio-chemical techniques to minimize quantum of saline effluent and to make use of saline water by encouraging the plantation of salt tolerant crops.

12.6 Undertake studies for salt balance build-up at micro as well as macro levels.

12.7 Carry out regular soil salinity surveys to monitor the salt position in the soils, particularly in zones defined as liable to sodicity (secondary salinization). Take effective steps to check further spread of sodicity, and appropriate measures to facilitate reclamation of lands already affected.

12.8 Accelerate work on the National Drainage Programme in consultation with the Provinces after identification and prioritization of zones infested with waterlogging and salinity.

12.9 Encourage participation of beneficiaries in cost-effective technologies and provide financial support, wherever feasible.

12.10 Complete all the four stages of RBOD to dispose of drainage effluent of Balochistan and the right bank of the Indus River in Sindh Province.

12.11 Align all new carrier drains away from canal command areas as far as possible.

13. WATER QUALITY

Issues

The so-called potable water is being supplied is far from meeting the WHO, EPA or other standards for potable water; hence the need for boiling and other types of domestic treatments adopted by many consumers in Pakistan, not to mention the rapidly growing market of bottled water.

Measures have to be adopted to eliminate contamination of surface water bodies and groundwater aquifers from industrial and domestic wastewater and pollutants, agrochemicals and urban sewage, all of which adversely affect water quality, natural ecosystems and public health.

The deteriorating quality of surface and groundwater resources has been given a lower priority to date than water quantity. However, quality will become an increasingly important issue and needs to be addressed. The objectives are to establish and maintain standards for potable/domestic water; ensure that effluent from wastewater is treated before disposal; and the preservation of surface and groundwater resources to ensure sustained supply.

Policy

To achieve the foregoing, it is necessary to:

13.1 Make the water quality in rivers, reservoirs, coastal areas and other water bodies including groundwater a national priority for improvement to acceptable standards by 2025 through improved agricultural drainage, municipal, rural and industrial wastewater treatment and effluent disposal. Achieve full compliance with EPA standards for drinking water.

13.2 Promote measures, as part of all future plans for water resources development that reduce or eliminate contamination of surface water bodies and groundwater aquifers from industrial and domestic emissions of pollutants, over-use of agro-chemicals and urban run-off, all of which adversely affect water quality, natural eco-systems and public health. Achieve full compliance with EPA standards for wastewater disposal.

13.3 Reduce the incidence of water pollution by regulating disposal of effluent in the municipal, industrial and agricultural sub-sectors.

13.4 Initiate a study to establish and implement a National Water Quality Monitoring Programme which will:

- Establish water quality standards for potable water and for surface and groundwater;
- Develop regulations for effluent disposal;
- Develop a comprehensive programme of water quality monitoring; and support the development of an Information Management System for data storage and assessment.

14. WETLANDS, ECOLOGY AND RECREATION

Issues

The protection and restoration of the natural environment and its biodiversity including wetlands, mangroves, national parks and river ecosystems should be a part of all future development and management strategies. All agencies responsible for the planning, design, implementation, operation and maintenance of water resource developments have to be responsible for enhancing and protecting environmental assets and amenities.

A review of existing environmental legislation (1997 Act, 1994 NEQS) indicates that the law is generally punitive rather than cooperative in nature.

Policy

Towards this end, there is need to:

14.1 Adopt an effective National Wetland Management Plan to ensure that endangered habitats are registered, monitored and managed according to the overall needs of wetland species. This requires that a detailed Wetland Survey be carried out in order to define the resources presently **available, and** identify incipient or future changes likely to occur as a result of current trends and anticipated future development.

14.2 Enforce the principle of "polluter pays" through strengthening of existing regulations for the protection of public health and environment.

14.3 Promote re-afforestation, soil conservation and improvement in land use of the catchments of storage reservoirs.

14.4 Minimize downstream as well as upstream environmental impacts, and embody appropriate measures as a part of the design of reservoirs and other development works.

14.5 Ensure that sufficient fresh water is flowing through the rivers to the sea to maintain a sound environment for the conservation of the coastal ecosystem and for the fresh and brackish coastal fisheries. Environmental needs must be addressed while framing "release rules" from the major storage dams for hydropower and irrigation, to ensure sustainability of such areas as the Indus Delta.

14.6 Promote the development of natural water bodies, where possible, for recreational use.

14.7 Ensure that there is sufficient water and of adequate quality for sustainable inland water for fisheries.

14.8 Review the existing environmental legislation (1997 Act, 1994 NEQS) with a view to render it more balanced in terms of positive versus punitive provisions.

14.9 Promote programmes for raising public awareness and community education about environmental needs and conservation.

15. INFORMATION MANAGEMENT AND RESEARCH

Issues

High quality and consistent data is required for sound planning. There are many agencies and institutions collecting land and water-related data in Pakistan. However, the data that is collected is not consolidated by any one agency and is often not easily available when needed by planning and implementing agencies, project stakeholders and the public. There is need to develop an integrated information system that coordinates the activities of all agencies so as to provide reliable data sets. Such a system needs to be based on modern lines and efficient procedures for collection, processing, retrieval and dissemination. In order to achieve this, there are many institutional and technical issues which need to be resolved.

Similarly, there are a number of key areas which require applied research to ensure sustainable development and utilization of water resources.

Policy

To achieve the foregoing, there is need to

15.1 Improve the national knowledge base by developing a national planning database which will:

a) **support an integrated information** system in order to place the planning and development **of water and land** resources on a sustainable base; and (b) consolidate information and data from all monitoring and research agencies.

15.2 Improve the quality of data through strengthening of monitoring organizations.

15.3 Encourage a policy of data sharing within and amongst all water-related organisations, and promote dissemination through Information Technology (IT).

15.4 Strengthen, promote and support public and private research organisations and universities to develop appropriate technologies or carryout research for:

- Conjunctive use of water;
- Soil conservation, catchment management and watershed protection techniques;
- Disposal of saline effluent;
- Water conservation measures and techniques;
- Maximization of resources;
- River training and erosion control;
- Land and water resource management.
- Curtailing conveyance losses;
- Improving irrigation efficiencies at distribution and at farm levels;
- Conservation of ecology of Indus Delta;
- Weather forecasting, rainfall predictions, flood forecasting, and drought forecasting techniques.

15.5 Improve the management of data and information at the national level by restructuring and strengthening existing responsible agencies, where appropriate, to undertake systematic data collection, processing, archiving and retrieval.

16. TRANS-BOUNDARY WATER SHARING

Issues

The optimal utilization of water resources of any shared basin, can only be achieved through agreements between co-riparian national administrations, and trans-boundary agreements between countries that share the resources of a common basin. The objective is to promote cooperation amongst co-riparian for sharing and long-term management of water, both under flood and drought conditions, and for control of pollution to improve water quality.

Policy

In order to foster co-operation for the management of common-basin resources, and to achieve good management of national resources, there is need to:

16.1 Work with co-riparian national administrations as well as with neighboring countries to better understand the overall river basin potentials and to develop appropriate strategies for their optimal usage and operation at all times, particularly during drought and flood conditions.

16.2 Work with neighbouring countries through international agencies such as UNDP/Global Environmental Facility (GEF) to prevent chemical and biological pollution by effectively managing industrial, domestic and agricultural effluent disposal.

17. INSTITUTIONAL AND LEGAL ASPECTS

Issues

In view of great importance of water in the national economy and limited additional resources, more efficient use of water needs to be ensured, particularly in agriculture related activities which consume over 90 percent of the total water quantity. Water is a provincial subject but many functions of an inter-provincial nature are the responsibility of the Federal Government. Provincial Irrigation and Drainage Authorities (PIDAs) are the custodians of the irrigation networks and are in association with Area Water Boards, as these are formed, supposed to carry out not only the operation and maintenance of the system and the distribution of water within their respective provinces, but also design and development of new irrigation and drainage works. This last function, over the preceding several decades, is being performed by WAPDA's Water Wing (a federal organization) at Lahore which is also carrying out overall planning of water resources on a national basis. Aside from WAPDA, there is another federal government organization, namely, that of Chief Engineering Advisor and Federal Flood Commission at Islamabad, to assist the Ministry of Water and Power in performing a number of engineering functions related to water.

In these provincial and federal set ups, there is considerable overlapping of activities and indeed some gaps as well, such as those relating to regulatory and monitoring functions. Design and construction of many irrigation works which are of strictly provincial nature, are being performed by WAPDA and, over the decades, provincial irrigation authorities have lost interest and consequently their ability to efficiently handle engineering design and heavy construction. The current system has both advantages and disadvantages. However, an overriding disadvantage is that when WAPDA has completed a provincial work, the provincial irrigation authorities find a number of deficient features and refuse to take over the completed work. WAPDA, on the other hand, does not always accept provincial irrigation authorities' viewpoint and thus controversies develop which do not get resolved for many years. In the meantime, WAPDA continues to maintain and operate the works bearing additional costs which become the responsibility of the federal government rather than of PIDAs. Even after the take over of Works, the provinces remain over-critical of several aspects of engineering designs, construction quality and operational features of WAPDA's Work. Federal agencies carrying out provincial water works, is also against the spirit of decentralization.

In order, therefore, to rectify the situation and to improve the efficacy of the system with clear-cut lines of responsibility, it is considered advisable to make certain basic institutional changes. Firstly and fore mostly, there does not appear the need for creation of any new organization. However, a merger of the following organizations, with proper strengthening, is envisaged for effective integrated planning and monitoring, and to avoid fragmentation of institutional responsibilities; (1) Office of Chief Engineering Advisor, and Federal Flood Commission (2) Part of Planning Organization of WAPDA's Water Wing dealing with integrated/overall planning (not the Design Cell or the Field Investigation set ups). Such an organization may be named as the Federal Water Commission and may preferably be located in Islamabad.

An apex body, namely Federal Water Council, is also being proposed for making decisions on water-related issues, however, such a body will be composed of part-time members, and as such should not be construed as creation of yet another organization. Same theme is proposed to be followed in the case of Provincial Governments.

Secondly, the newly-created autonomous Provincial Irrigation and Drainage Authorities (PIDAs) and **the Area Water Boards (AWBs),** must gradually create and strengthen their design and construction organizations, relieving WAPDA (a similar autonomous organization) of the undesirable burden of provincial work. In case PIDAs/AWBs wish that a particular type of heavy-construction work be performed by WAPDA, the implementation mode should be more or less akin to deposit work with provincial organizations as the client and WAPDA providing consultancy/construction management services under properly-executed agreements. WAPDA's Water Wing will, of course, continue to carry out inter-provincial construction and engineering, hydropower development and operation, besides other activities of specialized nature.

Thirdly, there is need for better coordination between irrigation and agriculture authorities. In order to provide for the desired linkages, PIDAs as well the federal organization responsible for integrated comprehensive planning, must have adequate representation of agronomists.

Fourthly, there is the dire need for providing institutional support at the provincial levels for urban domestic water and sanitation to ensure long-term planning, cooperation between urban service Providers and to support the weaker smaller cities and towns. Effective institutional and legal provisions are also required for the rural and industrial water supply sectors, and for the control of pollution of water bodies.

And finally, there are too many Acts, both at the federal and provincial levels which have been passed from time to time to cover the water-related enactment needs. For instance, at the federal level, there is the WAPDA Act 1958, IRSA Act 1992, and Environmental Protection Act 1997. At the provincial level, there is Punjab Irrigation Act 1873, Sindh Irrigation Act 1879, NWFP Act 1873, Balochistan Ordinance 1980, Punjab Soil Reclamation Act 1952, Water Users Association Ordinances 1981 and 1982, PIDA Acts of 1997, etc. These laws were appropriately enacted to cater for particular situations spread over more than a century. There is now the need to review, update, add, delete, modify various provisions to eliminate duplication and to include new provisions to cover the much-changed conditions and ground realities.

Policy

Towards the foregoing end, there is need to:

17.1 Create a high level inter-provincial permanent body at the federal level, composed of part time members, to be responsible for all water-resource matters. This apex body may be designated as Federal Water Council. The proposed Council would be composed of concerned **Ministers/Secretaries** of Federal Governments, Provincial Representatives and Stakeholders representatives as Members, and may be headed preferably by the Prime Minister or his nominee.

17.2 Merge the following existing organizations and designate the integrated set up as the Federal Water Commission:

- Office of Chief Engineering Advisor.
- Part of Planning Organization of WAPDA presently responsible for integrated/ overall planning.
- Federal Flood Commission.

The Commission shall be the secretariat of the proposed Federal Water Council and, for obvious reasons it may be headquartered in Islamabad. The Federal Water Commission will be responsible for:

- ❒ All secretariat work to assist the apex Federal Water Council.
- ❒ Implementation of the National Water Policy and Strategy.
- ❒ Integrated planning of water-related activities in the fields of Irrigation and Drainage works financed by the Federal Government, in addition to Flood Control and Hydropower for optimal and economic use of national water resources.
- ❒ Coordination of water-resource management activities among various water sector agencies throughout the country.
- ❒ Monitoring functions pertaining to federally-financed activities in Irrigation, Drainage, Flood, Droughts and Hydropower Sectors, and overseeing utilization of water resources at the national level, particularly in terms of sub sector-wise prioritization.
- ❒ Establish a National Database (Integrated Information Management ServiceIIMS), for which strengthening of WAPDA Water Wing's planning organization would be required prior to its transfer and merger under the Federal Water Commission.
- ❒ Assist in resolving inter-agency and inter-provincial conflicts.
- ❒ Ensure that the provincial agencies promote the stakeholders' participation in various fields of water resources.
- ❒ Carry out all flood protection functions as already entrusted to the Federal Flood Commission, including preparation and updating of national flood protection plan, review of infrastructural flood damages and plans for restoration and reconstruction. Create Provincial Water Councils and Commissions similar to the new set-ups at the federal level. The Provincial Council will be a high-level body handling all water-related provincial matters including irrigation, domestic water (both urban and rural) and sanitation, industrial water and wastewater disposal to prevent contamination of water bodies. The Provincial Water Councils will be of permanent nature but composed of part-time members from concerned Government Ministries, Organizations, Agencies, Experts and Farmers Representatives for high-level decision-making, periodic review, coordination and monitoring. The already existing permanent organizations of the water sector such as the residual Provincial Irrigation Departments, would act as secretariats of such a Council in each Province.

17.4 Enhance PIDAs/AWBs capabilities in engineering design and construction of provincial irrigation and drainage schemes such that they are able to implement their own projects timely and efficiently, thereby leaving WAPDA's Water Wing to concentrate on the inter-provincial construction work. In case a province feels that services of WAPDA are mandatory for the implementation of a particular project, PIDA/AWBs as a client should enter into proper consultancy/construction management agreements with WAPDA for services to be rendered. WAPDA's Water Wing will continue to perform design, construction and operation & maintenance functions on all inter-provincial projects, including hydropower development and other work of specialized nature.

17.5 Review and improve upon the organizational structure vis-à-vis the functions of Water Wing of WAPDA, in which many adhoc changes have taken place over a long period of time. The purpose is to make the organization more dynamic and responsive.

17.6 Carry out a study to explore various possibilities for improving coordination between many organization both at federal and provincial levels that are currently engaged/concerned with research on water-related subjects, to avoid duplication, to make organizations to abide by a prioritized research agenda on need basis, and to enhance productivity. Such institutions include Pakistan Council for Research on Water Resources (PCRWR including DRIP), Irrigation Research Institute (IRI) of Punjab Irrigation **Department,** International Waterlogging and Salinity Research Institute (IWASRI), Centre of Excellence of Water Resources (UET, Lahore), PARC, etc.

17.7 **Encourage and support** combining the appropriate provisions of various Water-related Provincial Acts, into one comprehensive Act. Such an Act would replace the existing provincial Acts, framed from year 1873 to year 1997, and would make the water-related laws concise and clearer, more-readily understandable and less susceptible to misinterpretations. ■

ANNEXURE 3
BRIEF DESCRIPTION OF BHIWA MODEL

The Basin-wide Holistic Integrated Water Management (BHIWA) model as evolved for CPSP has nine computation modules. The model is developed in Microsoft EXCEL software and has a number of spreadsheets. The model works, initially, in the calibration mode using the observed data. After obtaining a generally satisfactory calibration mode, it is worked as a tool for assessing the possible status of the basin, under different scenarios in the simulation mode. This process is depicted in Figure A1. For using the model, a river basin is first to be divided into hydrologically homogeneous sub- basins and each sub- basin into a number of land parcels each depicting a particular category/sub-category of land use. The model accommodates a maximum of 5 sub- basins and each sub- basin can be divided into a maximum of 25 land parcel types. The hydrologic computations are first performed for each land parcel in terms of water depth in millimeter over the area and then aggregated in volume units (million cubic meters) at the sub- basin level.

Natural (Hydrologic) Module 1: Computation of Actual ET, Quick Runoff and Natural Recharge

The model calculates water balances for the upper and lower zones viz. soil profile and groundwater system for each land parcel, given soil moisture holding capacity of the parcel, and area averages of rainfall, and reference evapo-transpiration for the sub-basin. The soil profile component of the model partitions the rainfall into actual evapo-transpiration (AET) and excess water. The actual ET is calculated as a function of potential ET and the actual moisture availability, as proportion of the root-zone soil moisture capacity for each land use type. These functional relations depict how the actual ET reduces with reduction of soil moisture availability, or indirectly the tension in the root zone. The excess water is further divided into deep percolation (natural recharge to groundwater) and quick runoff from land areas to the river. The quick runoff from all land parcels is aggregated into a single entity to represent natural contribution from rainfall to the river system. Likewise, natural recharge to groundwater under various land categories is lumped into a single groundwater entity representing the natural contribution of rainfall to the groundwater.

Module 2: Computation of Irrigation Withdrawal

This module calculates the requirement of additional water for each of the irrigated land parcels using data from previous module on shortfalls to meet the PET requirements. Net and gross irrigation requirements are computed source- wise using data on irrigation system efficiencies and proportion of surface water irrigation. For parcels having paddy crop, net water requirements are calculated taking into account user prescribed monthly percolation. Estimates of withdrawals for irrigation are arrived at finally considering “deficit irrigation” specified, if any.

Module 3: Computation of Irrigation Returns

These are computed separately for surface water and groundwater irrigation systems using user specified information on potential return from the total water withdrawn, in excess of the actual evapo-transpiration (AET) and that part of the wasteful return, that will be lost as ET from swamps/waterlogged areas with in cropped lands. The difference between the potential and the wasteful return is further divided into the components returning to surface and groundwater system.

Module 4: Accounting for Evapo-transpiration (ET) by Sector

This module is designed for accounting ET by different use sectors. This is achieved through sectoral identification of each land parcel type. Agriculture land parcels are further divided into rain-fed and irrigated parcels. Parcel ET is designated as beneficial, if it is productive from consideration of sectoral water use. Otherwise it is classified as non-beneficial.

Module 5: Computation of Domestic and Industrial Withdrawals, Use and Returns

In calibration mode, this module is run on directly fed data. However, in simulation mode, D&I module is used first to project population and water requirements in the targeted “future” year from the user given information on base year, intermediate blocks, population growth rates and proportion of urban population to total population.

Withdrawals are next computed in the model using rural and urban water supply norms and source-wise proportion of supplies. Information on consumptive use fraction and returns is used to calculate the total return as well as its components to surface and groundwater systems.

Module 6: Computation of the River Water Balance

It aggregates all inputs to the river including quick run off, base flow and returns from irrigation, D&I withdrawals and computes balance flow taking into account given values of storage changes and requirements of environmental flow. Provision exists to account for adjustments in surface water withdrawals through assumption of induced recharge from the river flow to groundwater in cases where the estimated groundwater withdrawal is found to be unsustainable. This module also has a provision to ensure that the river flow in any month is not less than the specified EFR, or zero, if no EFR is specified. This is achieved through extra pumping from groundwater reservoir to take part of the demands on surface water.

Module 7: Computation of Groundwater Balance

The input part of the module facilities aggregation of input from deep percolation from natural rainfall, return from irrigation and D&I withdrawals and as well as induce recharge if any required from the river. The output components of groundwater system include base flow to river and withdrawals through pumping from ground water reservoir as also pumping into canals to meet the surface water shortages, if there be any. In the simulation mode, the module is designed to achieve a stable groundwater regime under average conditions by adjusting the initial groundwater reservoir storage. Where the total annual input to groundwater is detected to be less than the estimated withdrawals including natural out flow (base flow) to the river, there exists a provision to manually balance groundwater through artificial recharge from surplus river flows for achieving a sustainable or balanced groundwater regime. Consequences of modifications in groundwater reservoir system are carried forward to modify the river water balance.

In addition to the above modules, there are worksheets to facilitate data inputs, and generation of aggregated results in the form of tables and charts.

The model runs on a monthly time step simulating average hydrological year. In the calibration mode, however, a model can be applied either to a single year (good, average or dry) or to a sequence of years (maximum length 5 years).

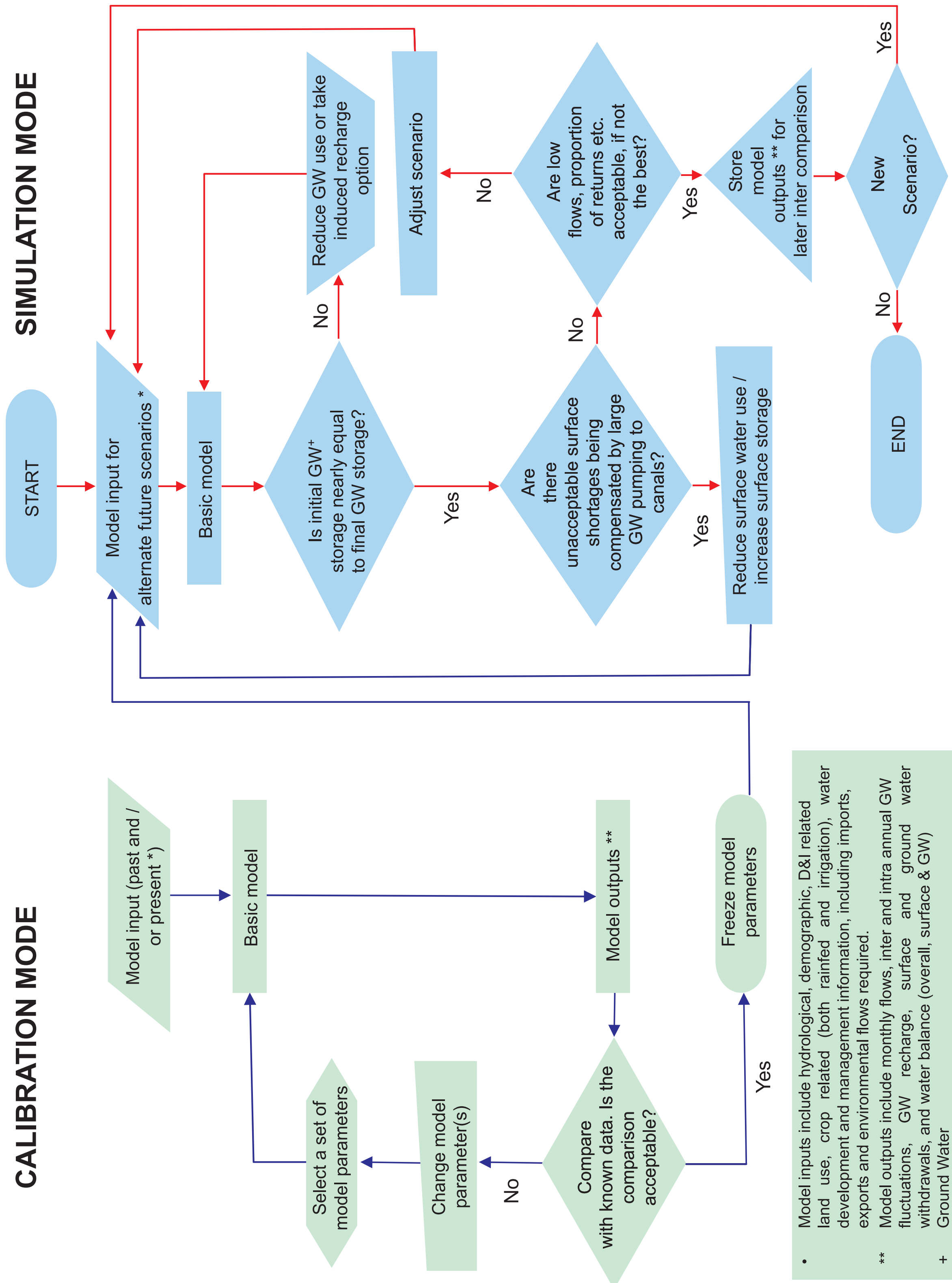


Figure A1. Logical Sequence of BHIWA Model

APPENDIX 4
APPLICATION OF BHIWA MODEL TO NARI RIVER BASIN

1.1 Nari River Basin

Nari River Basin of Balochistan province of Pakistan has been selected for the present study. Nari River Basin forming a part of Kachi Catchment of Balochistan province, drains about 22,560 sq.km (8,710 sq.miles) between longitude 67° 10' to 69° 47' E and latitude 29° 26' to 30° 55' N. The river originates from Toba Kakar Range and abodes lofty peaks of about 3,000 m (10,000 ft), which receive snowfall in winter. The catchment area receives rainfall both in summer and winter by monsoon and westernly disturbances respectively. The river receives flow from numerous hill torrents, which drain Quetta, Sibi and Loralai areas and outfalls into Kachhi plain near Sibi. Main towns of the basin are Loralai, Harnai, Duki, Ziarat and Sibi.

1.1.1 Crops Grown in Nari Basin

Presently, Nari River Basin is a water deficit. The major crops grown in the Nari River Basin area include wheat (52%), followed by fruits (25%) and other cereals (7%). Figure A2 shows the percent distribution of various crops in the Nari River Basin. Other cereals include maize, millet, barley and sorghum, mainly cultivated for fodder purpose. Fruits are cultivated only in the irrigated areas of the Nari basin. The quantity of water used (133 million Cubic Meter) can only meet one third of the crop water demands of the existing crops in the Nari River Basin. This amount of water is not sufficient to meet the crop water demands of the area. Only 35% of the total water demands are met with this quantity of water. About 80% crops are cultivated using surface and or groundwater, while remaining 20% are cultivated through the rainfall.

1.2 Sub-Basins of Nari River Basin

There are five natural sub-basins in the Nari river basin namely, Beji, Anambar, Dabar, Khost and Loe Manda. For the modeling purpose, the Nari River basin was grouped into three sub-basins based on the outlet points of flow measuring. The river discharge leaving the Anambar sub-basin is measured at the Ghatti bridge, so it is selected as a single unit, whereas Beji and Dabar is grouped into single unit as their combine discharge is gathered at the Babar Kach. Similarly combine discharge from Khost and Loe Manda leave the sub-basin and joins with the Beji River to

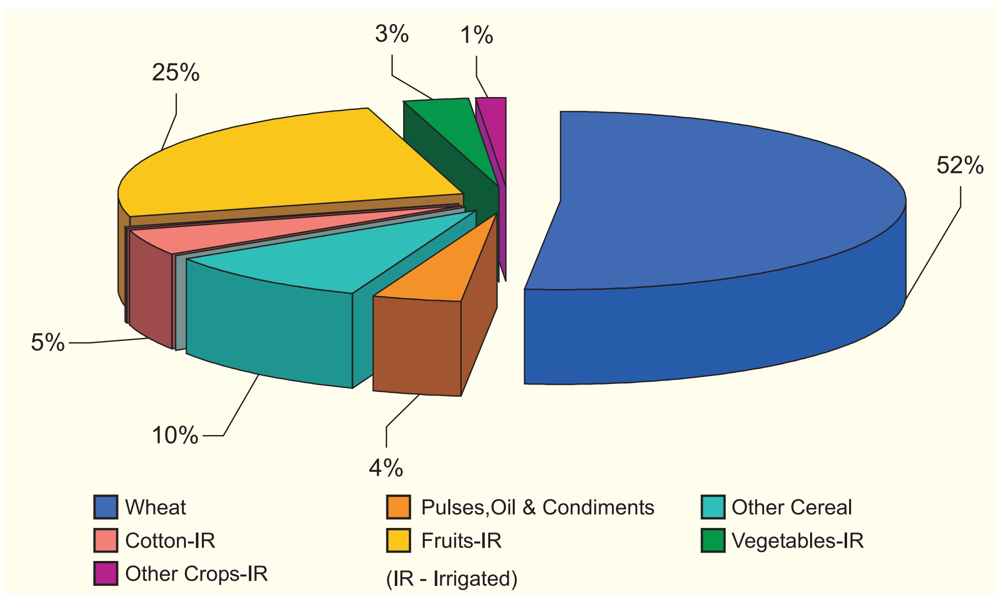


Figure A2. Percentage Distribution of Various Crops Grown in the Nari River Basin

form the Nari River. The location of Nari Basin is shown in Figure A3 and sub-basins within the Nari Basin is shown in Figure A4.

1.3 Water Resources of Nari River Basin

1.3.1 Surface Water Resources

The major source of surface flows is direct rainfall over the catchment area. Sometimes, it is supplemented by runoff generated by snowmelt. However, the major part of water availability is surface runoff resulting from rainfall. The pattern and distribution of rainfall and its quantity do not match the crop water requirements. In order to develop sustained agricultural system in the area, availability of water has to be ensured as per requirements and needs of various crops/orchards.

Nari River Basin is relatively a high precipitation area as compared to the other basins in the province. The average rainfall varies from about 130mm (5 inches) in the south to about 400mm (16 inches) in the northeast with an average of about 250 mm (10 inches). Nearly 6-16 freshets are encountered each year in the Nari River basin. The table A1 shows the surplus flow available at the basin outlet.

Table A1
Rainfall in the Nari River Basin

Sr. No.	Return Period (Year)	Average Basin Rainfall (mm)	Surplus Flow (Mm^3)
1	2.33	312	1,050
2	05	408	1,504
3	10	484	1,874
4	25	590	2,342

1.3.2 Groundwater Resources

Despite the size of the Nari Basin, there remains only a small groundwater development potential. Only two out of five sub-basins contain groundwater readily accessible from alluvial or piedmont 0deposits. Elsewhere these deposits, where they occur are of insufficient depth of any scale difficult or impossible. There may be scope for limited development using shallow dug wells only. A number of sub-basins contain no alluvial material at all, and are predominantly hard rock areas. Although these areas may generate and contribute to base flow from river; this results from gradual seepage from dispersed 'aquifer' storage in shallow weathered horizons and from fractures in the hard rocks. Although the high base flow in the Khost River suggests groundwater availability, the deposition of groundwater storage in the Ziarat, South West, Harnai and Sharig sub basins is such that this groundwater is not readily available for development. From various reports it is evident that the basin is being mined at a rate of 5.80 Mm^3/yr. However due to insufficient data regarding the inflow and the outflow, the groundwater balance is entirely based on the assumptions.

1.3.3 Agriculture Water Use in the Nari River Basin

There are 52 perennial irrigation schemes in the Nari Basin with an aggregate diversion of 10.8 m^3/ses (380 cfs). These schemes have been constructed from time to time since 1955 and are located in different tributaries of Nari Basin. The yearly diversion of these structures is about $94x10^6$ m^3 (76,000 acre-ft). The total area under cultivation through these structures is about 18,050 ha (44,600 acres). Most of the cultivated area is under orchard or cash crops.

There are five flood irrigation schemes in Nari Basin with a total diversion capacity of about 71 m^3/sec (2,500 cfs). The area under cultivation through these structures is about 1,380 ha (3,400 acres), with an average yearly diversion of about 21x 10^6 m^3 (17,000 acre-ft)

Fourteen delay action dams have been constructed in the Nari Basin to serve as a source of recharge to groundwater reservoir. The total storage capacity of these dams is about 3.7 x 10^6 m^3 (3,000 acre-ft). The stored water is allowed to seep and is exploited in the downstream areas by Karezes, open dug wells with pumps or shallow tube wells. In a year, these reservoirs are filled from about 6 to 16 times due to freshets. Delay action dams serve as a very good sustainable source of irrigation and provide irrigation facilities to about 2,000 ha (5,000 acres) in the Nari Basin. The average yearly utilization of water through delay action dams in the basin is about $20x10^6$ m^3 (15,000 acre-ft).

In addition to 71 water conservation schemes, 12 flood protection schemes have been constructed in Nari Basin to provide protection to about 12,000 ha (30,000 acres) of agricultural area. The total utilization of water through the existing water conservation structures is about $133x10^6$ m^3 (108,000 acre-ft) per year.

1.3.4 Domestic and Industrial Water Use

The present population of the Nari River Basin is about 1 million and the water requirement for this population is about 20 million cubic meters. This water demand is

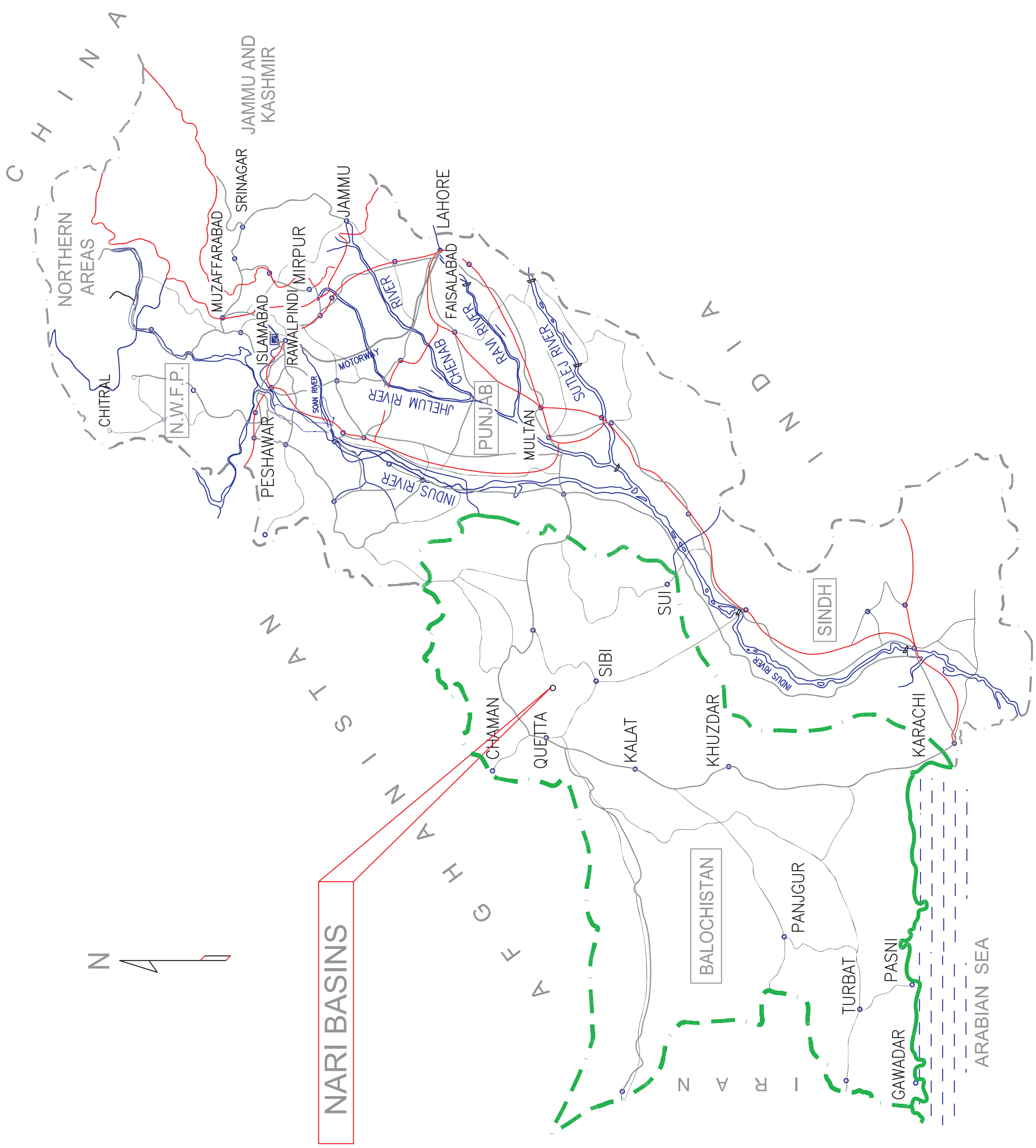


Figure A3 Location of Nari River Basins

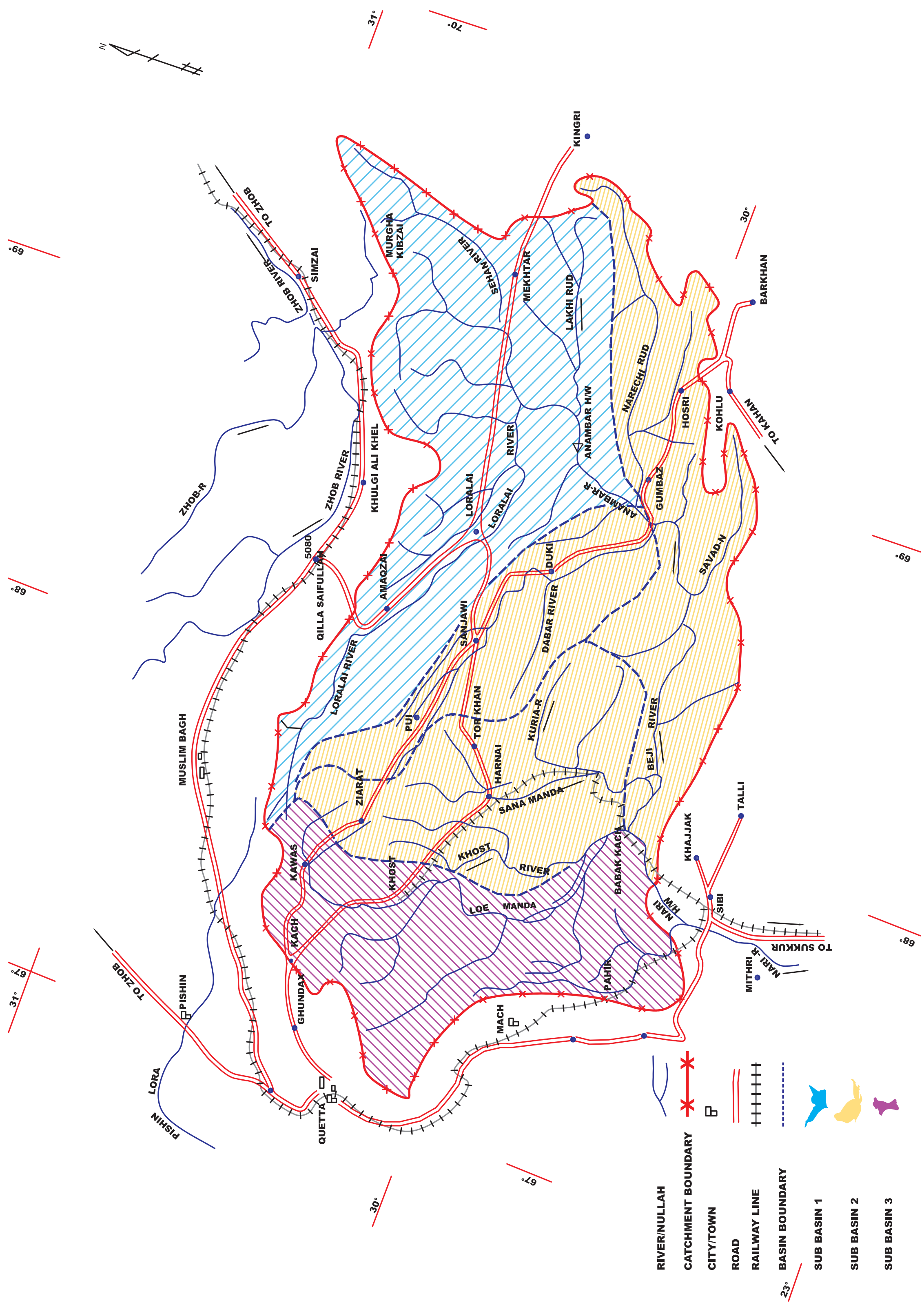


Figure A4 Sub-Basins in the Nari River Basin estimated based on 60 lpcd supply (Balochistan Groundwater Resource Reassessment, Final Report 1996). The domestic water consumption includes water for drinking, washing, bathing, sanitary and other purposes. The industrial water usage in the area is almost negligible. The non-agricultural water includes water for domestic (65%), industrial (2%), public use (7%) and livestock (1%). It also includes the wastage (25%) of water going to surface and groundwater bodies.

1.3.5 Land and Water Resources Development Potential in Nari River Basin

Water availability through out the year is the single major constraint to increase the cropped area in the Nari River Basin. About 327,355 hectares are currently fallow, showing the great development potential for irrigated agriculture in the area. Similarly 394,425 hectares are culturable waste, a good portion of this waste can be used for agriculture, if not all of this area is possible to use. Table A2 shows the land development potential in the Nari River Basin

Table A2
Land Development Potential in the Districts Falling in the Nari River Basin (Hectars)

Districts	Fallow Area	Culturable waste	Total
Pishin	50,283	38,784	89,067
Lorali	98,837	67,425	166,262
Musakhel	3,900	14,554	18,454
Barkhan	18,130	43,825	61,955
Zhob	21,308	82,322	103,630
Sibi	112,385	141,156	253,541
Ziarat	4,820	5,511	10,331
Kohlu	17,692	848	18,540
Total	**327,355**	**394,425**	**721,780**

(Source: Development Statistics of Balochistan, 2000-01)

The water development potential in the Nari river basin varies from 1,050 to 2,342 Mm^3 under various return periods. Keeping in view the lowest return period of 2.33 years, the surplus flow will be 1,050 Mm^3. Out of this river water flow leaving the Nari River Basin, a development potential of 544 Mm^3 exists in the basin.

II APPROACH TO BASIN WATER RESOURCES ASSESSMENT

2.1 General

The Country Policy Support Program (CPSP) looks at water resources in the context of coordinated development and management of water, land and related resources, integrating the needs of various human uses including vital needs of terrestrial and aquatic eco-systems. Policies and programmes in other sectors particularly those dictating land use influence not only demand on resources but also have implications in the availability of water supplies. For example, expansion of irrigation to new lands including conversion of rain-fed lands to irrigated lands, and barren lands to forestlands; tend to increase evapo-transpiration and hence reduce the total water availability.

Similarly, rainwater harvesting and soil & water conservation practices both in irrigated and non-irrigated or rain-fed condition; influence the total as well as inter-distribution of surface and ground waters. Impact of internal changes in land use as well as policies and programs in regard to soil and water conservation can be properly tested only when overall water balance for the entire land phase of the hydrologic cycle is studied. Furthermore, dry season flow in rivers is contributed by shallow aquifers. In India, groundwater use for agriculture is slowly turning out to be a major component in some basins. Since such use affects the base flow in rivers besides causing depletion of water tables, separate water accounts are needed for the river-surface and ground-water systems to achieve integration of supply sources and consider interaction between the surface and ground water components. The hydrologic model for the basin level assessments was evolved to cater to this broader need and for integration of water and land resources for sustainable use.

2.2 Methodology

The general step-by-step approach for basin assessment and consultation for CPSP is as follows: -

- Collection and preliminary processing of data.
- Setting up and validating a hydrologic model for the basin.
- Simulating responses for the past and projected future scenario(s).

- Assessment of water availability, and water uses for the past, present and future likely scenarios.
- Discussing the preliminary findings in basin level consultation.
- Suggesting policy changes to realize a desirable and practicable future scenario.
- To study the water needs of 'people' sector for sample cities to project future urban/ industrial demands.
- Holding consultations with Government and International Funding Agencies.

2.3 The BHIWA Model: Introduction and the Attributes

The development of the Basin-wide Holistic Integrated Water Assessment (BHIWA) model was guided by the approach to the CPSP studies as outlined earlier and keeping in view the data availability and time constraints. The model was envisaged to have the following attributes:

- Simplicity, in concept.
- Capability to deal with the entire land phase of the hydrologic cycle, from precipitation to ET and outflow to sea including withdrawals & returns
- Flexibility, to allow depiction of changes in land use, as also human interventions through irrigation.
- Capability to depict surface and groundwater balances separately and to allow depiction of interaction between them as also impacts of storage and depletion through withdrawals.

The need for depicting the entire land phase, stems from basic hydrologic premise that precipitation (and not river flow/ aquifer recharge) constitutes the primary resource, and evapo-transpiration management to increase the flows in rivers/ aquifers is a potential development strategy which could be encouraged through policy intervention, either for improving river flows or the traditional resource. At the same time, on demand side: consumptive use was considered as the indicator of the sectoral use rather than the water withdrawal. The study team therefore preferred a model that would depict land use changes and also allow the accounting of water use by the natural vegetation in non-agricultural lands for supporting terrestrial ecology, as also the water use by rainfed agriculture towards water for food and possibility of better deployment of rainwater through harvesting on such lands. The schematic diagram of the BHIWA model, is shown in Figure A5.

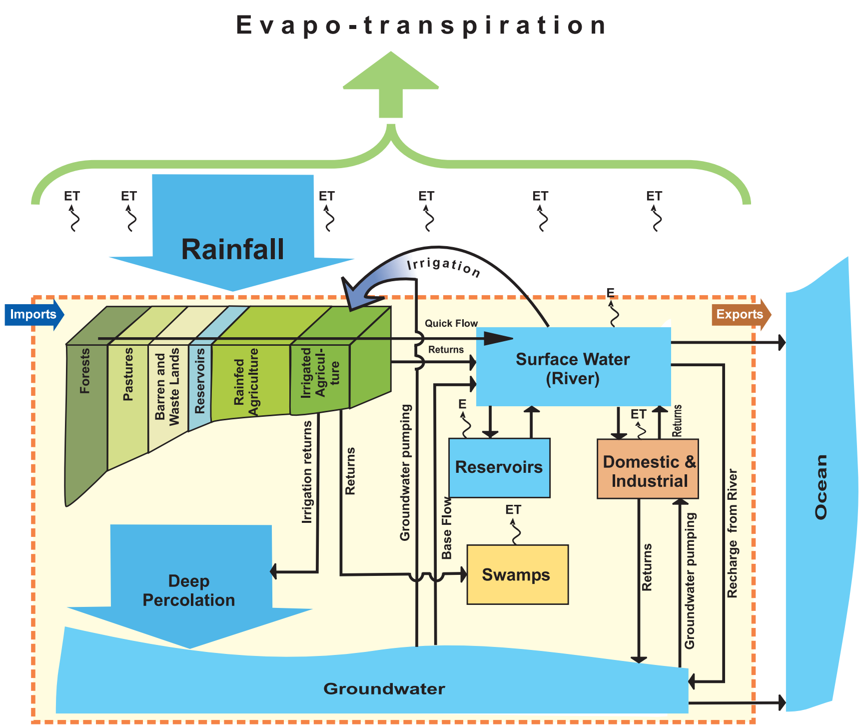


Figure A5. Schematic Diagram of BHIWA Model

III MODELLING OF NARI RIVER BASIN

3.1 Introduction

Nari River Basin was selected for detail study by considering the water situations and data availability. BHIWA model was calibrated for the present conditions (2001) and applied to derive responses corresponding to future scenarios using monthly time steps. Nari River Basin was further divided into three sub-basins namely Anambar (SB-1), Beji plus Dabar (SB-2) and Khost plus Loe Manda (SB-3) by considering the flow measuring stations. As the most of the data required for model calibration and simulation work is available on administration units level and not the basin level, another module is available with the model to convert the this information to basin wise. Table A3 shows the percentage of administration units falling in the Nari River Basin.

3.2 Basic Data Inputs

For using the BHIWA model, Nari river basin was divided into three sub basins and each sub basin was divided into several homogeneous land parcels. The working of the model is scenario-wise. For each scenario, the land use pattern for each parcel in each sub basin should be identified and data should be prepared accordingly for input to the model. The model provides for a maximum of 5 sub basins and 25 parcels for each sub basin. A maximum of 10 scenarios can be studied at a time in the model.

The following types of data are required as an input to the model:

- *Hydrological and climatic data* - Monthly data on rainfall, reference evapo-transpiration, and runoff data at locations near sub basin outlets (Refer Annex 5, 6 and 7 respectively), groundwater information on recharge and fluctuation etc.
- *Land Use* - Areas of forests, grasslands, barren and fallow lands, reservoirs and agricultural lands.
- *Crops Statistics* - Gross and net areas under agriculture and irrigated agriculture; crop-wise compositions of both; cropping calendar; source wise composition of irrigated area.
- *Agronomic Data* - Soil moisture capacities, K factors (crop coefficients).
- Information about withdrawals and returns for irrigation use and D&I use.
- *Demographic information* including growth rates.
- *Water Development related* - Surface storage changes, Imports and exports
- *Environmental* – Monthly environmental flow requirements (EFR)
- *Other Parameters* – Proportion of excess flow to surface; Index for soil moisture balance; Recession coefficients of linear ground water reservoir.
- *Water Use Related Parameters* – Irrigation system efficiencies for surface and ground water; Distribution of return flows to swamp evaporation, surface and ground water.

Table A3
Areas of Different Administrative Units in the Nari River Basin

Name of District	Area of district (Sq.Km)	SB1		SB2		SB3	
		(%)	(Sq.Km)	(%)	(Sq.Km)	(%)	(Sq.Km)
Kohlu	7,610	-	-	29	2,170	-	-
Loralai	17,260	36	6,268	15	2,555	-	-
Pishin	7,874	-	-	-	-	1	99
Kila Abdullah	3,238	-	-	-	-	26	827
Sibi	9,613	-	-	26	2,516	39	3,795
Zhob	20,297	-	-	5	1,106	83	2,724
Ziarat	3,301	15	500	-	-	-	-
Total	**69,193**		**6,768**		**8,347**		**7,445**

3.3 Land Use Types Used in the Model

Table A4
Land Parcels Used in the Model

P1	Forest & Miscellaneous Trees
P2	Permanent Pastures
P3	Land not available for Cultivation, Waste, & Fallow
P4	Land under Reservoirs
P5	Rainfed Kharif Paddy only
P6	Rainfed Two Seasonal (Kharif+Rabi)
P7	Rainfed Perennial
P8	Rainfed Other Kharif + Rainfed Rabi
P9	Rainfed Other Kharif only
P10	Rainfed Other Kharif + Irrigated Rabi + Fallow
P11	Irrigated Kharif Paddy only
P12	Irrigated Perennial
P13	Irrigated Two Seasonal (Kharif+Rabi)
P14	Irrigated Two Seasonal (Rabi+HW)
P15	Irrigated Other Kharif + Irrigated Rabi + Fallow
P16	Fallow in Kharif + Irrigated Rabi + Irrigated HW
P17	Fallow in Kharif + Irrigated Rabi + Irrigated HW Paddy
P18	Irrigated Rabi only
P19	Irrigated Other Kharif only
P20	Irrigated Other Kharif + Fallow Rabi + Irrigated HW
P21	Fallow in Kharif + Rainfed Rabi

3.4 Model Calibration

Owing to time and data constraints, rigorous calibration of the model was not attempted. The model was calibrated for last five-year data (1997 to 2001) and model calibration was limited to match with the following situation.

- Comparing the model computed outflow of SB-I with the observed flow of Beji River at Ghatti Bridge.
- Comparing the Groundwater recharge in the SB-I with the known recharge in the Loralai Sub- Basin.
- Comparing the model generated agricultural water use in SB-I with the known water use
- Comparing the model computed outflow of SB-II with the observed flow of Beji River at Babar Kach.
- Comparing the model computed outflow of SB-III (include all basin) with the observed flow at Nari/ Sibi Bridge.

Table A5
Observed Flows at Different Gauging Stations ($10^6 m^3$)

Year	Ghatti Bridge (SB-II)	Babar Kach (SB-II)	Nari Bridge (SB-III)
1993	325	185	1048
1994	NA	NA	1320
1995	489	234	1782
1996	237	177	666
1997	503	173	NA
1998	301	154	1979
1999	55	145	1057
2000	212	111	406
2001	328	206	1561
Average	**306**	**173**	**1227**

Figure A6 shows the monthly comparison between the observed and computed river flows for the sub-basin 1 of Nari river basin.

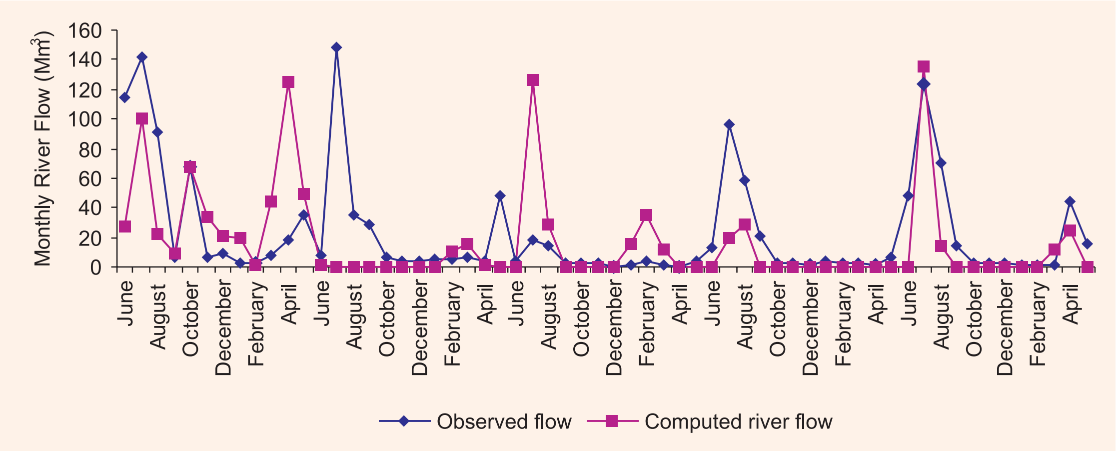


Figure A6. Comparison of Observed and Model Generated River Flows in SB1

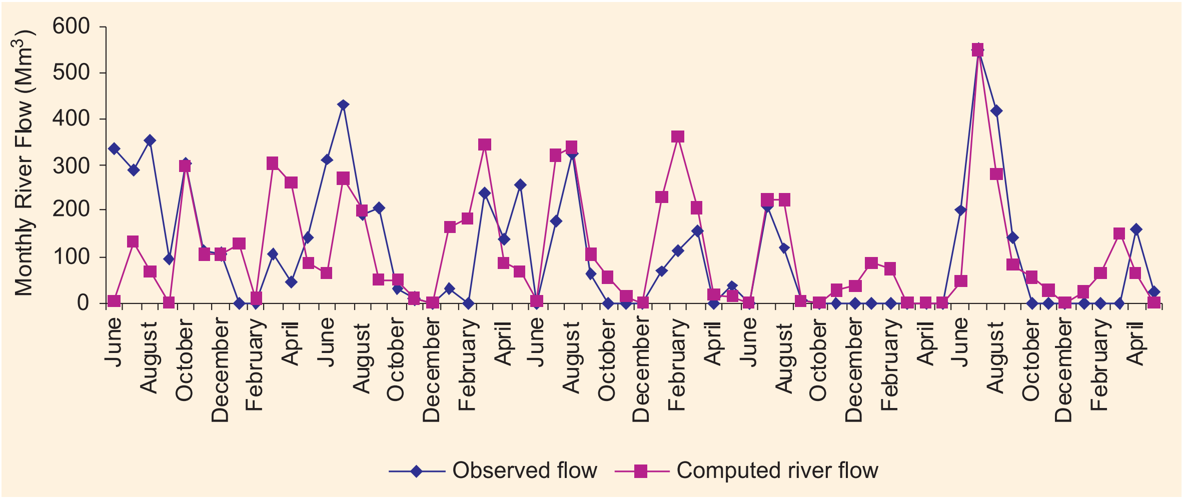


Figure A7. Comparison of Observed and Model Generated River Flows in Nari River Basin

The overall average of observed and model generated river flows for the five years (1997-2001) data is shown in Table A6 and Figure A7.

Table A6
Comparison of Model Generated and Observed River Flows

Sub-basin/ Basin	Computed (Mm^3/year)	Observed (Mm^3/year)
SB-I	200	280
SB-II	274	299
Total basin (including SB-III)	**1300**	**1336**

Tables A7 and A8 shows the comparison between the observed and computed recharge and groundwater withdrawals respectively.

Table A7
Comparison of Model Generated and Observed Groundwater Recharge

Sub-basin/ Basin	Computed (Mm^3/year)	Observed (Mm^3/year)
SB-I	56.6	56.4
SB-II	0.00	8.00
Total basin (including SB-III)	**108.0**	**NA**

Table A8
Comparison of Model Generated and Observed Groundwater Withdrawals

Sub-basin/ Basin	Computed (Mm^3/year)	Observed (Mm^3/year)
SB-I	42.00	41.26
SB-II	13.00	8.00
Total basin (including SB-III)	**63.00**	**NA**

The general validation of the model was accepted with the following values of main parameters:

1. Soil moisture storage capacity: varies with soil type and land use: 150 mm for forests, 75mm for agricultural lands (but 150 mm for paddies) and 40 mm for bare lands or land put to other uses. Higher capacity values would lead to higher evapo-transpiration and lower flows after rainfall has ceased, thus giving a better calibration but values higher than these were not tried as such capacities were unlikely to be available.

2. The excess water was assumed to be going to surface and groundwater bodies. The portion of this water is assumed different for the three sub-basins. For SB-I, reasonable recharge occurs and the portion of excess rainfall water is assumed to be 80% contributing to

Table A9
Description of Scenarios

S.N	Abbreviation	Explanatory Note
1	**Past**	Around 1993
2	**Present (2001)**	To date
3	**BAU**	Business as usual: with past trends of irrigation expansion, changes in cropped area present contribution of groundwater to total irrigation, while keeping the present cropping pattern.
4	**Future -II**	No increase in area but to reduce the groundwater contribution in "Anambar" SB-I.
5	**Future-III**	No changes in cropped area but to mange the existing land and water resources more efficiently by 2025 through more reliable water supplies. It includes the development work to construct storage/delay action dams (127 Mm^3 storage), flood irrigation schemes and other water conservation structures. The groundwater contribution to total irrigation will be further reduced
6	**Future-IV**	Same as Future-III but changing cropping pattern to have more irrigated rabi crops.
7	**Future-V**	Same as Future Scenario-III but increase in area as business as usual
8	**Future-VI**	More storage, 544 Mm^3 for flood control no increase in area.
9	**Future-VII**	More storage, 544 Mm^3 for flood control, shift in cropping pattern to have more irrigated crops.
10	**Future-VIII**	Medium storage, 190 Mm^3, promoting afforestation and trees area.

surface flows whereas 20% was assumed to be going to the surface water. Whereas for the remaining two sub-basins (SB-II and SB-III), having little groundwater recharge the excess water is assumed to be 95% contributing to quick runoff.

3. A groundwater recession coefficient of 0.25 for SB-I and 0.5 for SB-II and 0.8 for SB-III were assumed depending upon the amount of base flow.

3.5 Model Simulation

3.5.1 Scenarios Studied

Table A9 shows the various scenarios studied. The land use, irrigated area, water use pattern for the past situation was not available as the area has been on mode of dividing for the last so many years and new districts have been established. So, due to the shortage of time, the data regarding past scenario could not be collected. Based on the growth rate in land and water use pattern, an approximation was made to represent the past situation around 1990. The year 2001 represent the present year situations. The present conditions indicate the actual state in the basin. The model was calibrated for both the present (2001) data as well as using a long-term data from 1996-2001. The different scenarios mentioned in Table A9 were formulated by considering the land and water indicators, improvements in water management practices and institutional reforms. The model was run on monthly basis and the land use data for various scenarios is shown in Figures A8 to A11. The overall, surface and groundwater resources annual water balance in Nari basin under steady state condition is given in Tables A10, A11, and A12 respectively.

3.6 Consumptive Use of Water

For the present condition, the total consumptive use is 1072 million cubic meters. It comprises nature sector (895 Mm^3), agricultural sector (172 Mm^3) and people sector (6 Mm^3). The agricultural use of 172 Mm^3 is made up of ET from rainfall and soil moisture, in rain-fed as well as irrigated lands, additional ET met from irrigation and reservoir evaporation. These include considerable non-beneficial ET in nature (553 Mm^3) and agricultural sectors (43 Mm^3). The reduction of non-beneficial ET through rain harvesting and soil water management can lead to a significant improvement in flows.

In the Business as usual scenario, total ET is 1371 million cubic meters. This consumptive use by the people sector will be double than the present situation. Similarly for agricultural sector, this consumptive use will be about three times more than the present situation. Consumptive use. In different future scenarios the amount of consumptive use

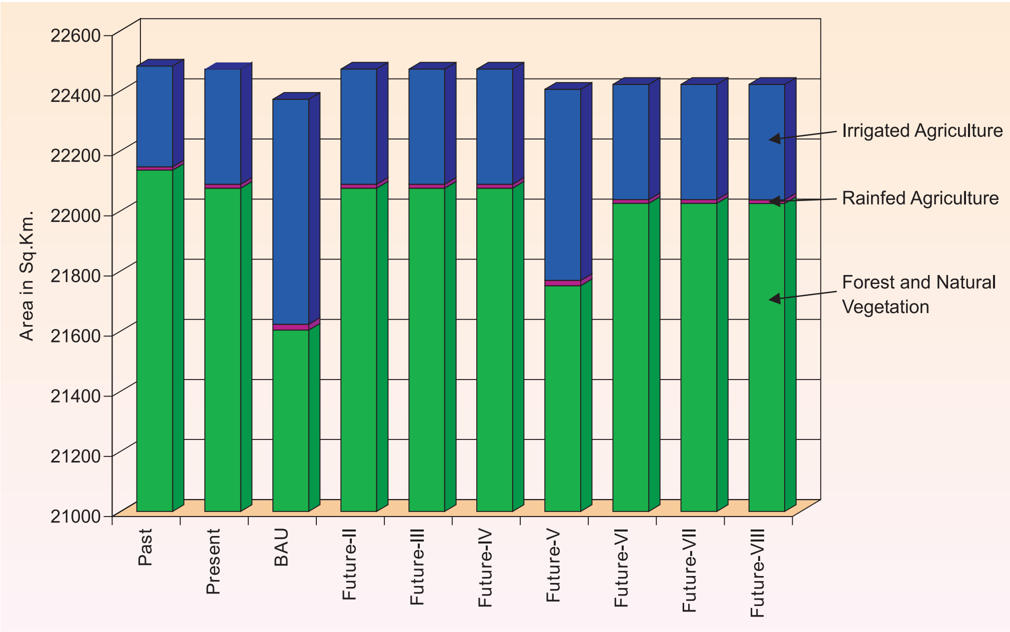


Figure A8. Distribution of the Net Land Area in Nari River Basin

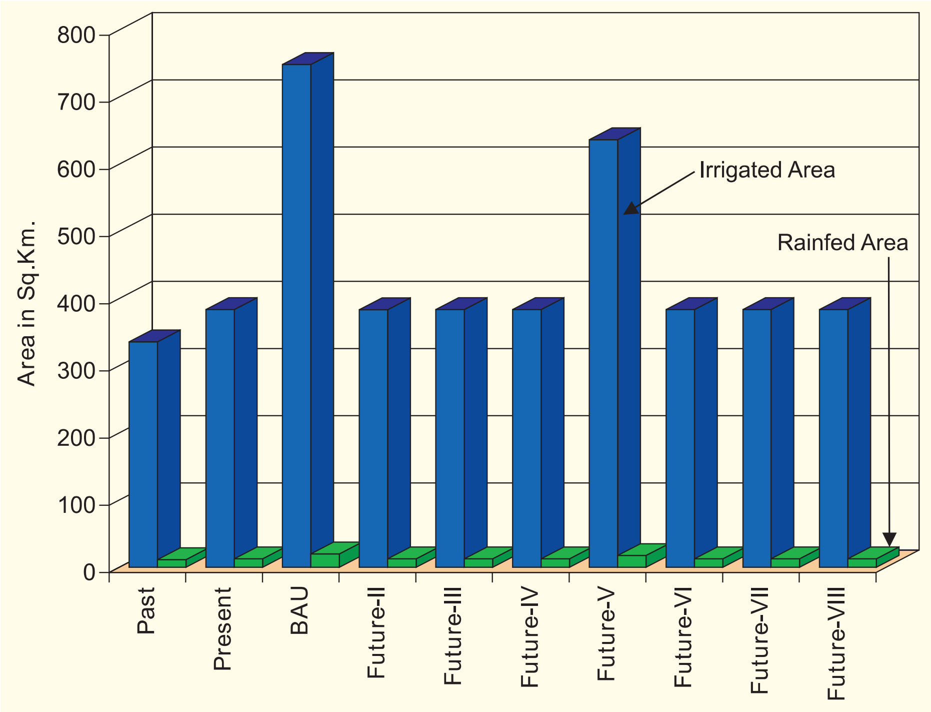


Figure A9. Net and Gross Cropped Areas - Irrigated and Rain-fed in the Nari River Basin

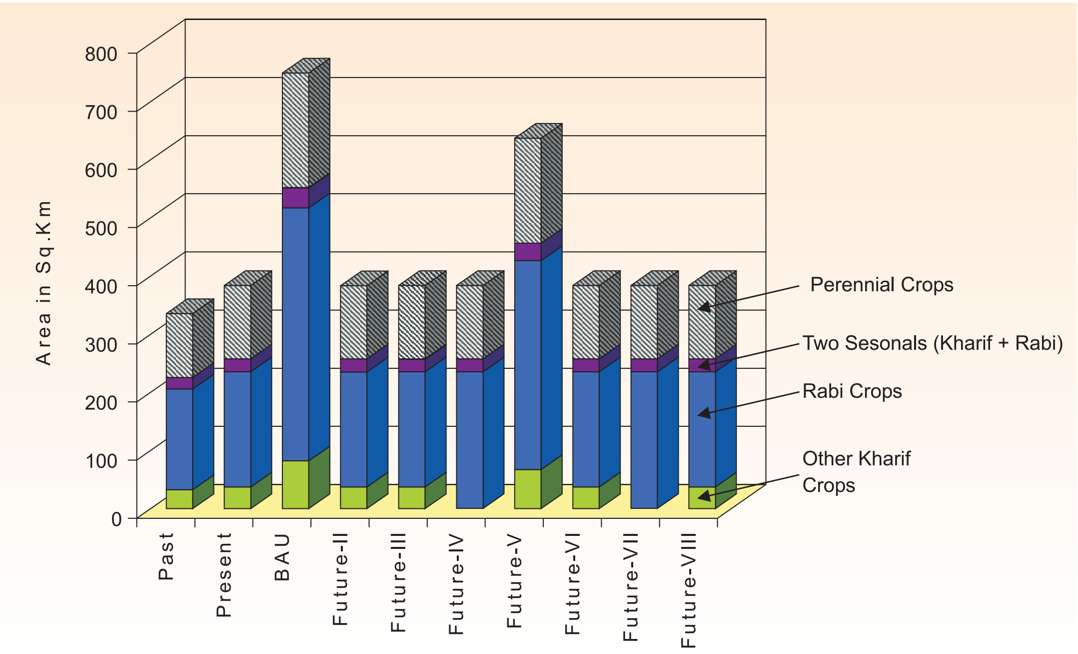


Figure A10 Distribution of GIA by Crops and Seasons in Nari River Basin

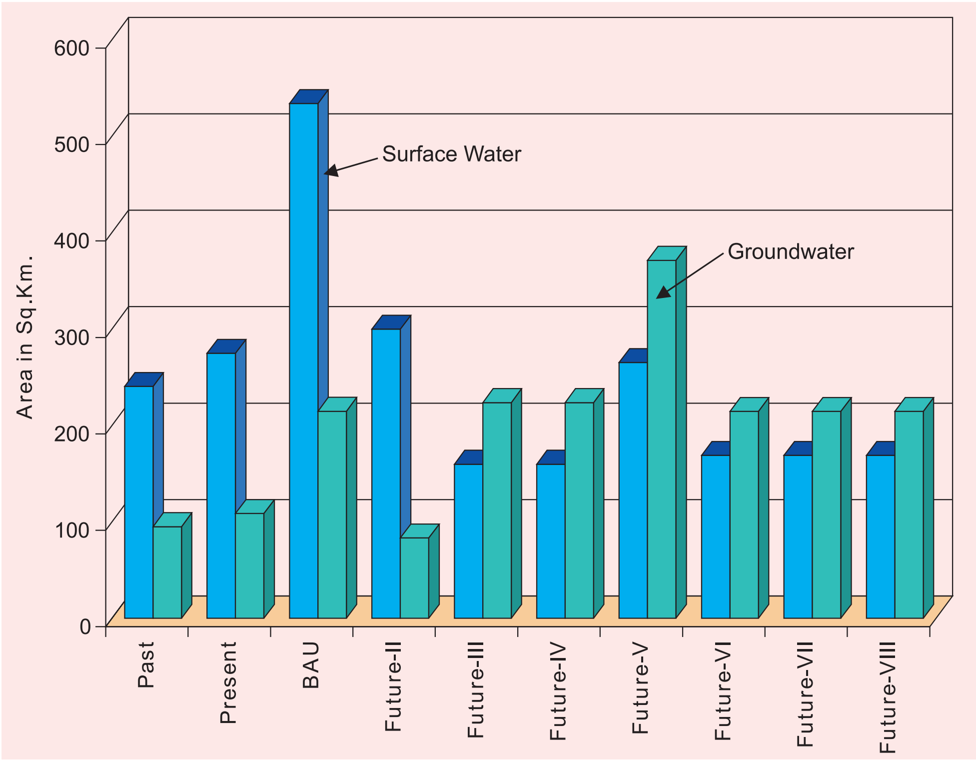


Figure A11 Net Surface and Groundwater Irrigated Areas in Nari River Basin

Table A10
Overall Annual Water Balance in Nari River Basin (Mm³)

	Past	Present	BAU	Future -II	Future -III	Future -IV	Future -V	Future -VI	Future -VII	Future -VIII
Inputs										
Rainfall	2,615	2,615	2,615	2,615	2,615	2,615	2,615	2,615	2,615	2,615
Imports	0	0	0	0	0	0	0	0	0	0
GW flow from other basins	0	0	0	0	1	0	0	0	0	0
Total input	**2,615**	**2,615**	**2,615**	**2,615**	**2,616**	**2,615**	**2,615**	**2,615**	**2,615**	**2,615**
Outputs										
Consumptive use total	1,050	1,072	1,371	1,182	1,155	1,145	1,281	1,164	1,154	1,425
River flows total	1,206	1,197	1,048	1,075	1,103	1,112	977	1,084	1,093	773
Export (surface)	0	0	0	0	0	0	0	0	0	0
GW flow to other basins	0	0	0	0	0	0	0	0	0	0
Direct GW flow to sea	0	0	0	0	0	0	0	0	0	0
Total output	**2,256**	**2,269**	**2,420**	**2,257**	**2,258**	**2,257**	**2,258**	**2,248**	**2,247**	**2,198**
Storage changes										
Surface storages	0	0	0	0	0	0	0	10	10	10
GW storage	1	11	158	1	0	0	2	1	1	0

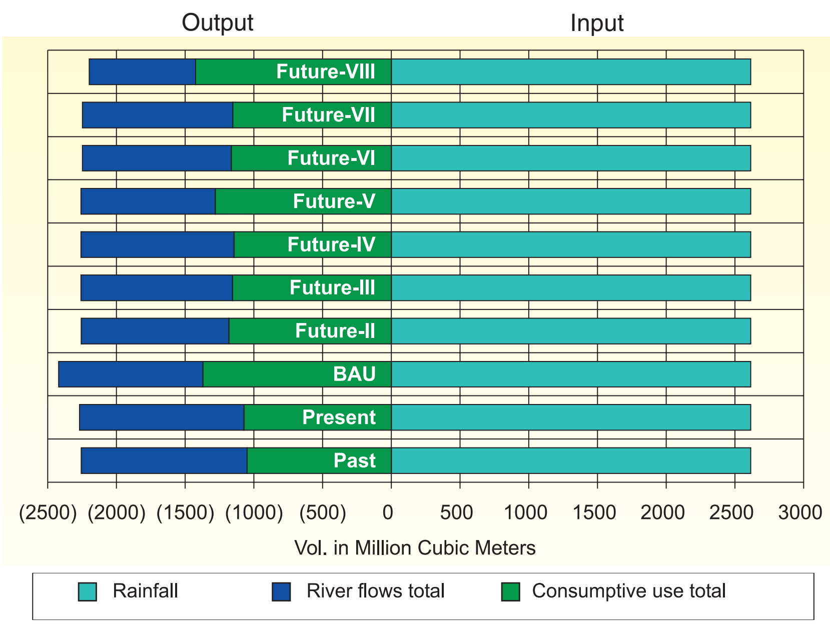


Figure A12. Overall Water Balances in Nari River Basin

Table A11
Annual Water Balance for Surface Water Resource System in Nari River Basin (Mm^3)

	Past	Present	BAU	Future -II	Future -III	Future -IV	Future -V	Future -VI	Future -VII	Future -VIII
Inputs										
Quick runoff from rainfall	1,209	1,206	1,181	1,206	1,206	1,206	1,181	1,199	1,199	903
Base flow	89	85	38	55	24	25	10	49	49	10
Returns to surface from surface irrigation	32	37	114	73	7	6	10	7	6	7
Returns to surface from GW irrigation	4	5	15	6	2	2	3	2	2	2
Returns to surface from D&I withdrawals	3	4	9	9	9	9	9	9	9	9
Sub-total, returns to surface	39	46	138	88	17	17	21	18	17	18
Imports	0	0	0	0	0	0	0	0	0	0
Total input	**1,338**	**1,336**	**1,357**	**1,348**	**1,247**	**1,248**	**1,213**	**1,265**	**1,265**	**931**
Outputs										
Surface withdrawals for irrigation in the basin	120	131	292	207	72	69	121	83	82	63
Surface withdrawals for D&I in the basin	6	9	17	17	17	17	17	17	17	17
Total surface wirhdrawals, for use in the basin	125	140	309	223	88	85	137	100	98	79
Natural and induced recharge from river to GW	7	0	0	50	56	50	98	71	64	69
Outflow to sea	1,206	1,197	1,048	1,075	1,103	1,112	977	1,084	1,093	773
Export	0	0	0	0	0	0	0	0	0	0
Total output	**1,338**	**1,336**	**1,357**	**1,348**	**1,247**	**1,248**	**1,213**	**1,255**	**1,255**	**921**

varies from 1050 to 1343 million cubic meters. Three future scenarios (II, III &VI) emphasize on better water resources management without increasing the crop area, whereas all the other future scenarios are accomplished with increase in crop area to cope with the increasing food demands. Table A13 summaries the composition of sector's consumptive use under different scenarios. Figure A13 shows graphically consumptive use by different sectors in Nari basin. The consumptive use of agricultural sector can be further classified by status of land (Rainfed or irrigated). Part of the consumptive use from irrigated land is met either from rainfall or irrigation water. Non-beneficial consumption would be from reservoirs, waterlogged areas, or from land without crops in particular season. For the present condition, out of total consumptive use (172 Mm^3), 7% contribute to rain-fed agriculture and irrigated lands from the rainfall consume 41%. Whereas additional use on irrigated lands from irrigation is 60% of the total consumptive use in the agricultural sector.

Table A12
Annual Water Balance for Groundwater System in Nari River Basin (Mm^3)

	Past	Present	BAU	Future -II	Future -III	Future -IV	Future -V	Future -VI	Future -VII	Future -VIII
Inputs										
Natural recharge from rainfall	108	108	105	108	108	108	105	107	107	89
Returns to GW from surface irrigation	32	37	114	73	27	25	39	26	25	26
Returns to GW from GW irrigation	4	5	15	6	34	32	50	44	41	44
Returns to GW from D&I withdrawals	5	8	13	13	13	13	13	13	13	13
Sub-total, returns to GW	41	49	142	92	73	70	102	83	79	83
Natural and induced recharge from river to GW	7	0	0	50	56	50	98	71	64	69
GW flow from other basins	0	0	0	0	1	0	0	0	0	0
Total inputs	157	157	247	250	238	228	305	261	251	242
Outputs										
GW irrigation withdrawals, including GW pumpig to surface canals	60	75	350	178	197	186	277	195	183	216
GW withdrawals for D&I use	6	9	17	17	17	17	17	17	17	17
Sub-total GW withdrawals	66	84	366	194	213	203	293	212	200	233
Base flow to rivers	89	85	38	55	24	25	10	49	49	10
GW flow to other basins	0	0	0	0	0	0	0	0	0	0
Direct GW flow to sea	0	0	0	0	1	0	0	0	0	0
Total outputs	**155**	**169**	**404**	**249**	**238**	**228**	**304**	**261**	**249**	**243**

3.7 Surface Water

In the present situations, total surface withdrawals in the basin are 140 Mm^3, which is 10% of the total inputs to the surface water system, whereas the return flows; contribute 3% of the total inputs. The contribution of return flows to the surface water system is not to such an extent to cause risk of pollution for downstream users.

For the future scenarios, the amount of surface water withdrawals will vary from 80 to 309 million cubic meters. The highest amount of surface water withdrawals (309 Mm^3) will be under business as usual scenario, which comprises 23% of the total inputs to the surface water body

Table A13
Consumptive Use (Evapo-transpiration) by Sectors (Mm^3)

	Past	Present	BAU	Future -II	Future -III	Future -IV	Future -V	Future -VI	Future -VII	Future -VIII
Nature sector, beneficial	341	341	341	341	341	341	341	341	341	682
Nature sector, non beneficial	555	553	540	553	553	553	544	552	552	472
Sub-Total	**896**	**895**	**881**	**895**	**895**	**895**	**885**	**893**	**893**	**1154**
Agriculture sector beneficial	113	129	369	214	214	203	321	204	193	204
Agriculture sector non-beneficial	38	43	110	61	34	36	62	55	56	55
D&I (People sector)	3	6	12	12	12	12	12	12	12	12
Total all sectors	**1,050**	**1,072**	**1,371**	**1,182**	**1,155**	**1,145**	**1,281**	**1,164**	**1,154**	**1,425**

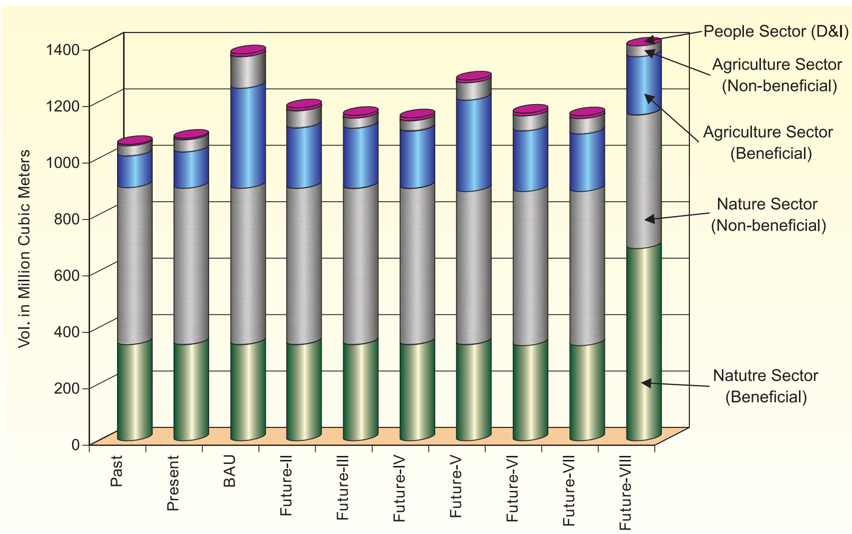


Figure A13. Consumptive Use (ET) by Use Sectors in Nari River Basin

system. The amount of return flows also varies from 2% to 10% of the total inputs for different scenarios. The highest amount of return flow (10%) will be under business as usual scenario, which will be causing severe risk of pollution to downstream waters. The other scenarios with management and/development interventions are not causing risks to downstream users. The total sustainable river flows after providing natural and induced recharge from river to groundwater for some selected scenarios is shown in Figure A14.

Better water resources management in the Nari river basin will result in eliminating the risks of floods causing severe threats to life and property of the people. The Figure A13 shows the regulated flows distributed to different months. With more storage (544 Mm^3) Future-VI and Future-VII and allowing depletion in dry months will ensure the availability of water throughout the year. The Future-VIII shows reduction in total flows available at the basin outlet. This is due to the use of rainfall water at two upstream sub-basins (SB-I and SB-III) by man made forests.

3.8 Groundwater

The groundwater resources in the Nari Basin are not in

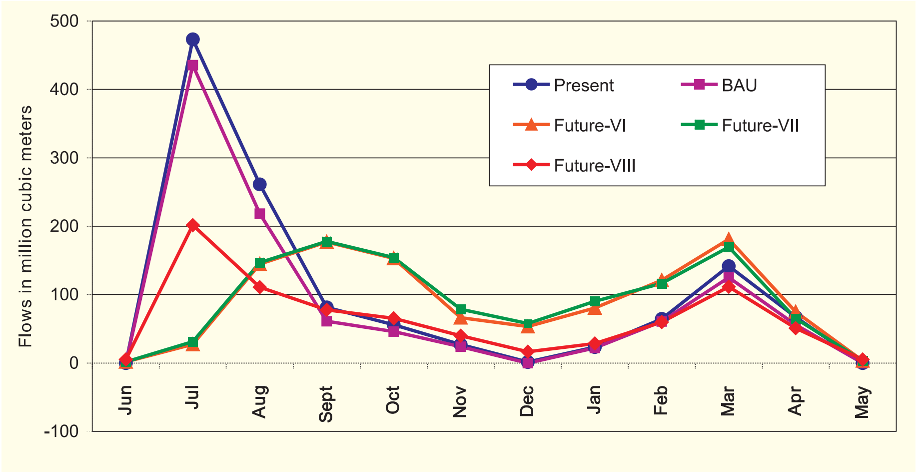


Figure A14. Monthly River Flows in Selected Scenarios

the extent to be exploited blindly. Mining of the aquifer in the basin has already been observed. In the current situations, groundwater withdrawals are 84 Mm^3, which is 54% of the total inputs to groundwater system. Total inputs include natural recharge from rainfall and return flows from irrigation and domestic and industrial water use. This amount of groundwater withdrawals will vary from 84 Mm^3 to 366 Mm^3 under various future scenarios. Presently the amount of base flow contributing to river flows is 84 Mm^3 which will reduce to as low as 10 Mm^3 under various future scenarios. Any groundwater development activity in the basin will reduce the amount of base flow moving towards basin outlet for downstream users. The groundwater outputs inclusive of base flow under present situations are 108% of the total inputs, which will further reduce to 164% under business as usual scenario. The return flow under various scenarios will vary from 31% (Present) to 55% (BAU), thus causing risk hazards to downstream water users. The withdrawals of both surface and groundwater for different purposes and for different scenarios are shown in Figure A15.

3.9 Groundwater Pumping and Induced Recharge

The water demands for agriculture, people and nature sector is met primarily from the surface water resources in the Nari River Basin. When the surface water is not available, additional pumping from groundwater to surface canals is required to be done to fulfill the crop and domestic and industrial water demands in the area. With this additional groundwater pumping to surface canals system, the sustainability of groundwater storage, under the average recharge conditions is disturbed. To have sustainable groundwater storage, the assumption of natural and induced recharge from surface to groundwater is used. The additional withdrawals from the groundwater to surface canals will be during the low river flow months, when not enough surface water available to be used. The surface flows for induced recharge will be available fin the high flow months. The scenario wise position about the need for groundwater pumping to canals for meeting deficits in surface water supplies and of natural recharge is given in Table A14. The amount of groundwater pumping to surface

Table A14
Requirements of Groundwater Pumping into Canals and Natural and/or Induced Recharge from River to Groundwater for all Scenarios

	Past	Present	BAU	Future -II	Future -III	Future -IV	Future -V	Future -VI	Future -VII	Future -VIII
GW pumping to canals	26	36	227	123	48	45	55	33	31	53
Natural and induced recharge from river to GW	7	0	0	50	56	50	98	71	64	69

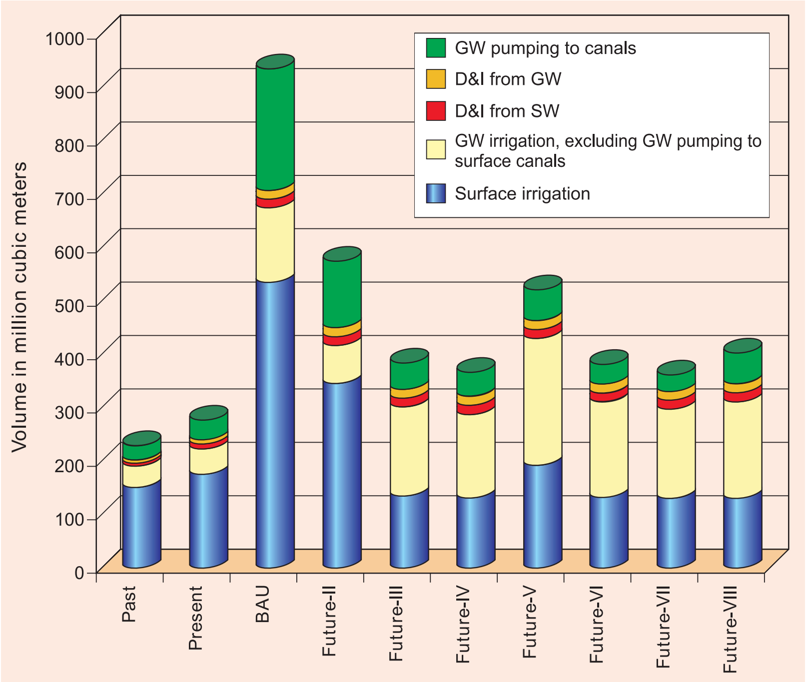


Figure A15. Composition of Water Withdrawals in Nari River Basin

canals will vary from 31 to 227 million cubic meters in different future scenarios. This additional pressure on groundwater resources will be met through the natural and induced recharge from surface flows. The amount of this recharge will vary from 50 to 98 million cubic meters. This recharge will be available through various development activities including delay action dams, diversion structures and storage dams.

3.10 Water Situation Indicators

In the model, four water situation indicators have been proposed to depict the level of water use (withdrawals) and potential of hazard (due to return flows) to water quality, as follows:

Indicator 1: Ratio of total surface water withdrawal to total surface water inputs,

Indicator 2: Ratio of total returns to surface water to total surface water inputs,

Indicator 3: Ratio of total groundwater withdrawals to total groundwater inputs, and

Indicator 4: Ratio of total retu4rns to groundwater to total groundwater inputs

Discussion about these indicators is given in CPSP Reports 1 and 2 (ICID, 2005 a,b). The indicators were further categorised into 3 to 4 classes each to represent the degree of water stress and quality as shown Table A15.

Table A16 presents the value of these four indicators for past, present and future scenarios. The water situation indicator-1 and 2 are less than 0.25, thus indicating no harm to surface water withdrawals and quality hazards for downstream water users. But the groundwater is at present under high threats of quantitative and quality hazards. This situation will further worsen under business as usual scenario, when groundwater obstruction will be 50% more than the total groundwater inputs. At the same time a higher value of indicator-4 will result in quality hazards to groundwater. For all the remaining future scenarios, there will be a little groundwater quality hazard but the ratio for indicator-4 will not exceed more than the present values.

3.11 Main Findings of Nari River Basin Assessment

1. In the future scenarios, water demands for people will be competing with other sectors. With the population growth rate of 2.38%, the water demands for people will increase to 33 Mm^3. This will also be causing stress to groundwater resources, if major portion of it is to achieve from the groundwater source. At present the industrial water demands in

Table A15
Water Situation Indicators

Indicator	Water source and type	Category	Value
1	Surface water withdrawal	Very high stress	>0.8
		High stress	0.4 – 0.8
		Moderate stress	0.2 – 0.4
		Low stress	<0.2
2	Surface water quality	High threat	>0.2
		Moderate threat	0.05 – 0.2
		Low threat	<0.05
3	Groundwater withdrawal	Very high stress	>0.8
		High stress	0.4 – 0.8
		Moderate stress	0.2 – 0.4
		Low stress	<0.2
4	Groundwater quality	Very high threat	>0.8
		High threat	0.4 – 0.8
		Moderate threat	0.2 – 0.4

Table A16
Water Situation Indicators for Nari Basin

	Past	Present	BAU	Future -II	Future -III	Future -IV	Future -V	Future -VI	Future -VII	Future -VIII
Indicator 1	0.09	0.10	0.23	0.17	0.07	0.07	0.11	0.08	0.08	0.09
Indicator 2	0.03	0.03	0.10	0.07	0.01	0.01	0.02	0.01	0.01	0.02
Indicator 3	0.42	0.53	1.49	0.78	0.90	0.89	0.96	0.81	0.80	0.96
Indicator 4	0.26	0.31	0.57	0.37	0.31	0.31	0.33	0.32	0.32	0.34

the Nari River Basin is nominal. If there would be a major shift in policies to have industrial zones in the Nari Basin area, the agriculture would confront the crisis of water shortage increasingly.

2. The model output shows that there is huge developmental potential of surface water resources. On an average condition the outflow to basin outlet is 1050 Mm^3. Out of this amount a considerable fraction can be stored through construction of delay action dams, diversion structures or storage dams to fully utilize the potential surface water resource.

3. About 61% of the river flow occurs during the two months of July and August. This unobstructed water sometimes causes severe flood like situation in the downstream reaches of the Nari River Basin, causing severe loss to property and lives of people and livestock. So for the flood protection measure, construction of small and medium storage reservoirs of total capacity of 544 Mm^3 could be helpful for flood mitigation measures and to attain more reliable surface water supplies in the dry months of the years.

4. Groundwater resources of the Nari River Basin are very limited. Few sub-basins have already shown mining situation especially in SB-I, where extensive use of groundwater for irrigation is causing threats to groundwater system as well as quality hazards for downstream users.

5. The amount of base flow (groundwater flow contributing to river flows) will be reducing under various future scenarios; the lowest will be under future-VIII, where full potential of water resources will be utilized to increase the crop area. This decrease in base flow will result in groundwater storage, although system ground water balance will be archived through the concept of artificial recharge. This reduction in base flow will be signifying the crisis of groundwater deterioration. ■

ANNEXURE 5
MONTHLY RAINFALL DATA IN THE NARI RIVER BASIN (mm)

RAIN GAUGE STATION: MURGAH KIBZAI

Month	1997	1998	1999	2000	2001
Jun	122	0	0	5	35
Jul	76	153	18	48	141
Aug	38	31	13	49	37
Sep	28	11	1	0	19
Oct	62	0	0	0	0
Nov	37	0	0	0	0
Dec	8	0	0	11	0
Jan	12	0	0	2	0
Feb	4	0	0	5	0
Mar	34	0	0	4	5
Apr	119	0	0	0	43
May	35	23	2	0	10
Total	**576**	**218**	**34**	**123**	**290**

RAIN GAUGE STATION: BABAR KACH

Month	1997	1998	1999	2000	2001
Jun	38	16	2	0	42
Jul	30	35	13	3	29
Aug	6	32	45	9	50
Sep	0	12	24	0	51
Oct	45	0	0	0	0
Nov	7	0	0	0	0
Dec	16	0	0	6	0
Jan	7	3	31	0	0
Feb	0	12	13	3	7
Mar	31	39	22	0	13
Apr	4	9	0	0	0
May	3	0	1	0	0
Total	**185**	**159**	**151**	**21**	**191**

RAIN GAUGE STATION: DUKI

Month	1997	1998	1999	2000	2001
Jun	9	16	9	5	2
Jul	109	14	54	8	46
Aug	3	0	21	24	0
Sep	0	1	0	0	3
Oct	28	1	0	0	0
Nov	0	0	0	0	0
Dec	19	0	0	0	8
Jan	15	9	40	3	0
Feb	0	19	33	2	9
Mar	56	24	11	2	13
Apr	56	27	0	0	2
May	49	21	7	0	0
Total	**345**	**131**	**176**	**44**	**82**

RAIN GAUGE STATION: HARNAI

Month	1997	1998	1999	2000	2001
Jun	12	12	1	0	8
Jul	14	35	0	8	80
Aug	0	17	68	34	5
Sep	0	0	0	0	2
Oct	28	0	0	0	0
Nov	21	0	0	0	0
Dec	25	0	0	24	0
Jan	48	42	25	26	0
Feb	9	18	38	12	13
Mar	68	47	0	0	6
Apr	4	1	0	1	2
May	2	15	0	0	4
Total	**232**	**187**	**133**	**104**	**120**

RAIN GAUGE STATION: ZIARAT

Month	1997	1998	1999	2000	2001
Jun	6	21	0	1	1
Jul	16	70	12	49	118
Aug	6	26	33	9	51
Sep	0	21	47	0	0
Oct	72	0	0	0	0
Nov	18	0	3	0	14
Dec	0	0	0	32	0
Jan	24	60	45	14	1
Feb	21	76	105	23	24
Mar	133	102	74	3	60
Apr	58	25	1	1	27
May	5	47	25	0	1
Total	**359**	**449**	**346**	**130**	**296**

RAIN GAUGE STATION: MACH

Month	1997	1998	1999	2000	2001
Jun	38	6	0	0	11
Jul	11	15	100	18	36
Aug	18	0	19	13	13
Sep	1	29	0	0	8
Oct	33	1	0	0	8
Nov	21	0	0	0	5
Dec	36	0	0	12	12
Jan	0	20	21	3	11
Feb	0	45	37	0	21
Mar	46	24	34	3	27
Apr	34	25	0	4	16
May	36	30	9	0	19
Total	**274**	**196**	**221**	**53**	**186**

ANNEXURE 6

MONTHLY OBSERVED RIVER FLOWS (Mm³)

GHATTI BRIDGE-SB1

Year

Month	1993	1995	1996	1997	1998	1999	2000	2001	Average
Jan	5	7	5	3	6	2	4	2	4
Feb	4	6	5	3	5	4	3	2	4
Mar	23	9	6	8	7	1	2	2	7
Apr	50	88	7	18	4	0	2	45	27
May	4	16	5	36	48	4	6	15	17
Jun	60	17	4	114	8	4	12	48	33
Jul	50	155	106	141	148	18	97	124	105
Aug	47	125	70	91	35	14	59	70	64
Sep	69	51	20	6	29	3	20	14	26
Oct	5	4	3	68	6	3	2	3	12
Nov	5	4	3	7	4	3	2	2	4
Dec	3	6	3	9	3	0	2	3	4
Total	**325**	**489**	**237**	**503**	**301**	**55**	**212**	**328**	**306**

BABAR KACH-SB2

Month	1993	1995	1996	1997	1998	1999	2000	2001	Average
Jan	12	7	10	5	9	11	5	6	8
Feb	9	7	9	3	11	13	5	4	8
Mar	9	7	13	8	12	14	5	4	9
Apr	23	23	7	11	10	6	5	21	13
May	9	11	14	16	14	11	7	18	13
Jun	16	14	18	42	15	6	6	20	17
Jul	48	67	42	22	28	27	23	38	37
Aug	17	55	25	19	16	26	27	39	28
Sep	14	12	15	15	13	9	8	29	14
Oct	9	13	9	14	9	9	7	9	10
Nov	9	8	8	9	8	7	6	9	8
Dec	9	9	7	9	8	5	7	9	8
Total	**185**	**234**	**177**	**173**	**154**	**145**	**111**	**206**	**173**

NARI BRIDGE-SB3

Month	1993	1994	1995	1996	1998	1999	2000	2001	Average
Jan	37	4	2	2	43	81	0	0	21
Feb	9	103	10	6	0	129	0	0	32
Mar	92	143	3	4	250	168	0	5	83
Apr	419	323	219	0	146	0	0	188	162
May	6	58	95	64	268	48	8	34	73
Jun	50	190	82	142	325	0	6	208	126
Jul	324	3	838	325	460	205	231	557	368
Aug	41	30	253	118	209	350	148	423	197
Sep	50	405	96	5	217	75	11	145	125
Oct	9	61	110	0	41	0	0	0	28
Nov	5	0	20	0	19	0	1	0	6
Dec	6	0	55	0	0	0	0	0	8
Total	**1048**	**1320**	**1782**	**666**	**1979**	**1057**	**406**	**1561**	**1227**

ANNEXURE 7

MONTHLY EVAPO-TRANSPIRATION (mm)

Month	SBI	SBII	SBIII
Jun	191	210	167
Jul	153	169	144
Aug	156	171	143
Sep	130	142	118
Oct	88	95	90
Nov	57	66	50
Dec	47	53	38
Jan	42	45	36
Feb	53	59	47
Mar	95	104	85
Apr	128	138	119
May	176	193	166
Total	**1315**	**1443**	**1202**

BIBLIOGRAPHY

Bhutta, M.N. (1999): Vision on Water for Food and Agriculture Pakistan Perspective, Regional South Asia Meeting on Water for Food and Rural Development, New Delhi, June 1-3, 1999.

Development Statistics of Balochistan (2000-01): Government of Balochistan.

Food and Agriculture Organization of the United Nations: Aquastat, http://www.fao.org/ag/agl/aglw/aquastat/water_res/pakistan/pakistan_wr.xlsational

Hussain, M (1995): Environmental Pollution.

International Commission on Irrigation and Drainage (2005a): Water Resources Assessment of Sabarmati River Basin, India, CPSP Report 1.

International Commission on Irrigation and Drainage (2005b): Water Resources Assessment of Brahmani River Basin, India, CPSP Report 2.

International Institute for Environmental and Development (1992): Environmental Synopsis of Pakistan.

International Waterlogging and Salinity Research Institute (1997): Integrated surface and groundwater management programme for Pakistan- Surface Water Interim Report No.98/1.

International Water Management Institute (1996): Severely Waterlogged Area in Pakistan (Unpublished Data).

National Engineering Services Pakistan (1997): Master Feasibility Study for Flood Management of the Hill Torrents of Pakistan, Supporting Volume V (Balochistan Province).

Pakistan Water Partnership (1999): Pakistan Country Report water Vision for the 21st Century.

Saleemi, M. A (1993): Environmental Pollution: Key Note Address at the International Symposium on Environmental Assessment and Management of Irrigation and Drainage Projects for sustained Agriculture Growth, Lahore, 24-28 October, 1993.