A PERSPECTIVE SCENARIO OF WATER FOR IRRIGATED AGRICULTURE IN PAKISTAN

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ABSTRACT

Pakistan is in need of assured irrigation supplies for successful agriculture due to arid and semi-arid climate and sporadic rainfall. The flow of Indus River and its tributaries constitutes the main source of surface water for the country. The flows in the rivers vary from year to year and winter to summer. Therefore, storage of water is of utmost importance for agriculture. Irrigated agriculture is contributing 26% of the GDP and accounting for more than 75% of the foreign exchange earnings. It provides employment to 54% of the labour force. Mostly the existing irrigation system was developed about a century ago, when the population was very little as compared to present. The beneficiaries of irrigation system have been increased manifolds. At the time of creation of Pakistan, per capita water was 5000 m^3/year and now it is estimated as low as about 800 m^3 per person/year. The food and fiber requirements of the country have been increasing in the past and will continue to increase in future as well. In the past increasing cropping intensities and crop production through increased supplies of water and other inputs fulfilled the increasing demands. The irrigation supplies were increased mainly from groundwater resource, which was created by the recharge mainly from irrigation system. However, the exploitation of groundwater has attained its maximum limit in many canal commands. Mining of groundwater has been observed in sweet groundwater zones. Scarcity of good quality water and salinization of land are main threats to the sustainability of irrigated agriculture in the country. The prolonged situation of drought has aggravated the water shortage at all levels. It is going to be a challenge to sustain irrigated agriculture to meat the mounting demands of future. There is a dire need to increase canal diversions, which would be only possible through increased storage capacity. Efficient use of good quality water and safe use of saline water should also be considered but these options have limited potential. In future the real challenge is food self sufficiency which has to be achieved through environmentally sustainable development with good sense of partnership between all stakeholders. The study recommendations are applicable in the irrigated agriculture of the Indus Basin.

1. INTRODUCTION

Water is the most precious resource on earth. Being a vital constituent of life, water with its diverse uses will continue to play a major role in reaching the broader developmental objective of achieving food security, poverty alleviation and improvement in the quality of life in the world, especially in the context of global population growth from five and a half billion in early 1999, to about 10 billion by the year 2025 (Tariq, 1999). The most prominent and the largest consumption of water among its multiple uses is in irrigated agriculture. Without agricultural growth, the rise in population would be far too large in relation to the productivity of the resource base, and the incidence of starvation and famines would increase, pressures on agricultural land and forests and rural outmigration would intensify demands on an already overburdened urban environment.

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Pakistan has one of the biggest contiguous irrigation systems of the world. Irrigated land provides over 90 percent of agricultural production and more than 75 percent of all export earnings is derived from agriculture. About 95 percent of the country's water resources are used by agriculture. It provides employment to 54% of labour force. But with rapidly increasing population, there is increasing demand for drinking water supplies as well as for increased food production. The domestic and industrial water use in the country is 5 percent at present and is expected to increase to 15 percent by 2020. Even though 80 percent of the withdrawals for these uses return to the system, the quality is degraded.

2. LAND RESOURCES

Out of the total geographical area of 79.61 mha of Pakistan, a considerable portion with 59.32 mha falls under total reported area which is a sum of forest area, cultivated waste land, uncultivated area and the area under cultivation. The real agricultural wealth of Pakistan however, lies in the lands of the Punjab and Sindh provinces. The major cultivated areas, in fact, lie in the Indus Basin. The total cropped, either irrigated or barani, in Pakistan constitute 23.04 mha; forests occupy an area of 3.59 mha; uncultivated areas, otherwise culturable lying waste for lack of water, constitute 22.04 mha. Pakistan has agricultural land potential of about 28.39 mha (GOP, 1999).

3. WATER RESOURCES

The water resources play a significant role in sustaining agro–socio–economic conditions of Pakistan. In the country the different sources of water are:-

3.1 Rainfall

The rainfall is highly variable with less than 10 cm in some parts of the country to more than 50 cm in other parts. Most of the rainfall occurs during monsoon period (July to September) in the form of torrential showers. Much of the summer rainfall is, thus, not available for agriculture because of rapid runoff. At other times the showers may be so light that precipitation evaporates before the water can penetrate to the root zone of crops. The contribution of rain to crops in the irrigated areas of the Indus Basin has been estimated at about 6 MAF. Rate of evaporation ranges between 150 to 200 cm annually. Without assured irrigation supplies large area of Pakistan cannot support agriculture, as rainfall is either meager or unreliable.

3.2 Surface Water Potential

The average annual inflow of the rivers is 145 MAF and the annual canal head withdrawals, on an average, are 105 MAF.

3.3 Groundwater Potential

The Indus plain's aquifer with an aerial extent of over 194250 sq. km has a great depth and is composed of unconsolidated alluvial deposits consisting of fine to medium sand, silt and clay. The aquifer also has very favourable physical characteristics and groundwater can be pumped from it quite economically. The quality of groundwater is highly variable both geographically and with depth. In the country more than 600,000 private tubewells of shallow depth and low capacity have been installed. These tubewells have played a significant role in augmenting the inadequate good quality water supplies. However, the information about private tubewells for different canal commands is missing.

As a consequence of such development, the groundwater pumpage in the Indus Basin has increased from 3.34 MAF in 1959-60 to 50 MAF in 1996-97 (GOP, 1999). An additional potential of about 10 MAF has been estimated in riverine areas. The annual groundwater potential of areas outside the Indus Basin is estimated as 1.41 MAF. Lowering of groundwater table in all the canal commands during the past four years indicate a negative groundwater balance in the Indus Basin and consequently inter-mixing of underground water in fresh and saline aquifers has started deteriorating quality pumped water.

4. WATER REQUIREMENTS AND AVAILABILITY

At the time of Pakistan's creation the quantum of surface water resources annually available per capita was about 5000 m^3. Now these resources have dwindled down to 800 m^3. Water availability falls short of crop water requirements by 40 and 108 and 151 MAF in the years 2000, 2013 and 2025 respectively (Table 1). Consequently, the agricultural production would also fall to meet the food and fibre demands of the ever-increasing population of the country. In the past wastages of water although were undesireable, yet those were affordable. Now, competing demands for water are increasing. If the nation does not stop wastage right now we shall be faced with the unthinkable prospect of food-shedding in a few years.

Table 1. Water Requirements and Availability in Year 2000–2025 (MAF)

	Year		
	2000	2013	2025
Population (millions)	137	176	208
Water Requirement			
Irrigation (Food)	143	206	243
Non-irrigation	6	9	11
Total:	149	215	254
Water Availability			
Total Surface and Ground	109	107	127
Shortfall	40	108	127

Source:

5. QUALITY OF WATER

The quality of different sources of water available in Pakistan vary considerably and is discussed as under:-

5.1 Quality of River Water

The chemical quality of waters of the rivers is excellent for irrigation, though it contain some soluble salts but contents vary for each river. The total soluble salts (TSS) range from 100 ppm during high flows to about 200 ppm during low flows. On the average 105 MAF of water is diverted to agricultural lands and it is estimated that 23.30 m tons of salts are being added to soil annually even through excellent quality canal water. As a result of different estimates about 116 m tons of salts are being added to cultural lands through canal and groundwater (Sufi et al., 1993). The data regarding quality of river water during winter and summer is given in Table 2.

Table 2. River Water Quality: highest values observed during winter/summer (ppm)

S.No.	Name of Sampling Site	1965	1985	1990	1991	1992	1993	1994	1995	1996	2001	2002
1.	Taunsa					170/						173/240
2.	Guddu			260/300	335/230						/141	175/169
3.	Sukkur Barrage		220/280	310/240	230/200						134/	178/168
4.	Dadu-Moro Bridge		272/482									180/180
5.	Sehwan			880/230	460/510	492/652	-	260/272	-	252/180		
6	Kotri Barrage		302/374	490/640	/173						/159	292/196
7	Trimmu					/140						250/250
8	Balloki H/W	/214	100		-	/100						258/258
9	Sidhnai	/256	150		-	/150						278/278
10	Panjnad	/198	-		/198	/130					/151	262/262

Winter / Summer
Winter = November to March
Summer = April to October
Source: SMO & IWASRI.

The data presented in Table 2 indicates the deterioration of water quality in the downstream direction which is primarily due to natural causes (evaporation, tributary inflows) because little irrigation drainage is returned to the river system at present. Although the current effects of agricultural use are negligible, yet industrial and municipal pollution is growing and has become severe in drains passing through urban and industrial areas including Karachi, Hyderabad, Lahore, Faisalabad and Rawalpindi.

5.2 Groundwater Quality

The quality of groundwater is highly variable in various parts of the country both vertically and horizontally from completely fresh to extremely saline. In total 50% of the Indus Plain is underlain by useable groundwater (Ahmad, 1993). Generally ground water is fresh in strips along the rivers because of seepage of fresh water and it deteriorates, towards centers of Doabs. The distribution of groundwater salinity in the Indus Plain is reported in Table 3.

6. SECONDARY SALINIZATION OF SOIL

Though, with the inception of Salinity Control and Reclamation Projects (SCARPs), waterlogging has greatly been reduced, the incidence of salinity is still to be controlled efficiently in many areas. It is a specific phenomenon of secondary salinization which does not seem to have been reversed or arrested so far. Salt balance for whole of Pakistan has been reported as building up because more salt is entering in the system than leaving. To combat this problem it is absolutely necessary to:

* Reduce the amount of salts being added in the system by disposing off highly saline groundwater by other means than the irrigation system;
* Increase supplies of fresh water to the farmers to improve the leaching of salts in soils;
* Make gypsum available to the farmers; and
* Grow more salt tolerant varieties of crops and trees.

Table 3. Distribution of groundwater salinity in the Indus Plain

Province	Area (mha) underlain by groundwater of salinity		
	<1500 mg L^{-1}	1500-3000 mg L^{-1}	>3000 mg L^{-1}
Punjab	6.84	1.34	1.66
Sindh	0.94	0.55	4.46
NWFP	0.35	0.05	-
Balochistan	-	-	0.28
Total	8.13	1.94	6.40

Source: Ahmad (1993).

7. MAJOR SUSTAINABILITY ISSUES

Major issues for the sustainability of irrigated agriculture are described in brief as under:

7.1 A Water Scarce Country

Pakistan was considered a country having per capita water more than the critical limit of 5000 cu meter per year. But Pakistan is entering in the list of water short countries. It will be a challenge for us to survive under water stress conditions.

7.2 Equity in Water Distribution

Equity in the distribution of water among the users in the canal command has been an operational objective of the management of the canal systems in Pakistan. In fact, there is inequity in distribution at all levels of the system. Within a watercourse command water delivered to the head farmers is generally 32 percent and 11 percent more than to the farmers at the tail and middle reaches respectively. Inequity in water distribution between head and tail is of the order of 20 percent to 50 percent. If this is the quantum of water, which is not available to these who deserve, it poses specific problems of scarcity on the one hand and waterlogging on the other. Similarly, outlet on a minor or distributary receives different amounts of water. Illegal pumping from canals and excessive losses add to the inequity in distribution (Mohtadullah, 1997).

7.3 O&M and Cost Recovery

Irrigation and drainage systems have been deteriorating due to deferred maintenance and utilization beyond design capacities. At present the recoveries are so meager that they cannot even take care of the normal operation and maintenance expenses. As a result, the allocations for the operation and maintenance have not kept at pace with the increasing costs and this has resulted in the progressive deterioration of the system. An evaluation of O & M costs of irrigation and drainage and recoveries in the Punjab Province, Pakistan has been made, which indicates that the O & M costs are increasing, while the correspondent recoveries are decreasing with the passage of time (Table 4).

Table 4. Operation & Maintenance Budget and Revenue Receipts from Irrigation and Drainage Charges, Punjab Province, Pakistan

Fiscal Year	O&M Budget M.Rs.	Revenue Receipts from Irrigation and Drainage Charges	
		(% of assessment)	M Rs.
1982-83	*	76	676.563
1983-84	*	71	597.232
1984-85	*	72	695.841
1985-86	*	69	663.174
1986-87	*	67	672.389
1987-88	*	62	653.576
1988-89	*	59	663.763
1989-90	*	49	583.170
1990-91	*	57	771.161
1991-92	1675.02	52	705.237
1992-93	2300.03	53	663.514
1993-94	2441.40	55	799.444
1994-95	3311.81	61	986.487
1995-96	3655.40	46	779.688
1996-97	4062.23	45	1131.196
1997-98	4625.99	43	1470.36
1998-99	5168.54	*	1569.22
1999-2000	4924.50	*	1889.56
2000-01	5350.00	*	*

Source: Punjab Irrigation Department. * Data missing

7.4 Environment Degradation

The issues regarding environmental degradation have been discussed as under:-

7.4.1 Waterlogging/Salinity

The extensive system of man made irrigation has also been responsible for some of Pakistan's principal environmental problems, such as waterlogging, salinity and sodicity. The continued recharge to the groundwater aquifer through seepage from canals, rivers and irrigated lands without adequate drainage, has resulted in the steady rise of watertable which has at places, even reached the surface. Salinity and sodicity, which usually follow waterlogging in regions with high temperatures and evaporation rates, are also claiming significant tracts of fertile land in the irrigated areas. Presently soil salinity is estimated to rob farmers of 25 percent of potential production of major crops.

7.4.2 Secondary Salinization

As already discussed it has been observed that in medium groundwater quality zones, which lie at the tails of distributaries and where canal supplies are limited due to silt deposition in the canals or diversion of greater quantities of water in the upper reaches of the canals, groundwater of marginal quality is used for irrigation in large quantities. Continuation of this practice over long periods of times gives rise to secondary salinization in the soils of the area. For sustainability of irrigated agriculture in these areas secondary salinization should not be allowed to occur and the normal canal supplies should be provided to these areas.

7.4.3 Salt Balance in the Indus Basin Aquifer

In arid and semi-arid regions the greatest threat to the sustainability of irrigated agriculture comes from accumulation of salts in the soils. Under ideal conditions the salts must be removed from an irrigation system at the same rate at which they are added to the system. If this does not happen the salinity in the soils and in the aquifer will continue to increase and it is only a matter of time when salinity shall become intolerable to plants.

7.4.4 Saline Water Intrusion

Possibilities of saline water intrusion in FGW areas from adjacent SGW areas also exist in the Indus Plain because FGW is found near to the rivers and in those areas where rainfalls are heavy, while areas away from these sources of recharge have SGW. Intrusion of saline groundwater in fresh groundwater areas has already occurred at a few places like Allahabad Unit of SCARP-VI in the Indus Plain.

7.4.5 Urban and Industrial Pollution of Water

Due to the growing population of the country, extremely poor condition of the municipal facilities including the disposal of domestic and other municipal wastes, growing use of fertilizers, pesticides and insecticides in agriculture and disposal of industrial wastes in drains and ponds, the chances of pollution of groundwater with municipal, agriculture and industrial pollutants has greatly increased. Besides its use for agriculture and industrial purposes groundwater is being used in Pakistan for municipal purposes on large scale.

Industries, agriculture and municipal sewage are among the major sources of water pollution. According to a very rough estimate 9000 million gallons of waste water having 20,000 tons of BOD loadings are daily discharged into water bodies from industrial sector. Similarly about 6.9 million tons of human excreta are annually produced. Two millions are annually produced in urban sector of which around 50% goes into water bodies to pollute them. Notable water bodies receiving industrial and domestic effluent include River Ravi, River Chenab, Deg Nullah, Bhed Nullah, Chicho Ke Mallian Drain, Barianwala Drain, Hudiara Nullah, Paharang Drain (Faisalabad), Naubahar Canal (Multan), Aik Nullah (Sialkot), Leih Nullah (Rawalpindi), Rohi Nullah (Kasur) etc. These are a few examples from the Punjab. In other parts of Pakistan River Kabul land Malir and Lyari Streams are greatly polluted. Resultantly our rivers, streams, drains, nullahs have become sewage conveyors experiencing severe water pollution downstream waste discharges. Water pollution problem is assuming serious proportion particularly around major urban centres. Environmental profile of Pakistan indicates that about 40% of deaths are related to water borne diseases. Research studies show that continuous sewage irrigation of an area with heavy solid i.e. organic content may destroy fertility of land and contaminate vegetables and groundwater. EPA Punjab studies indicate that sizeable downstream stretches are being polluted with high BOD and TDS and low D.O. (Saleemi, 1993).

7.4.6 Soil Erosion

Soil can be eroded by water or wind. Water erosion is most severe on hillsides, and along riverbanks. Some of the erosion is the result of long-term natural processes, but it has been accelerated by various abuses, notably the depletion of natural vegetation and excessive tillage. Over 11 million hectares are estimated to be affected by water erosion. Similarly wind erosion is also a serious problem, affecting about 5 million hectares.

7.4.7 Evaporation Ponds

Besides, the potential impact of saline drainage effluent on wetlands there is the water environmental concern about the disposal of salinity into evaporation ponds or back into the river or canal system. Evaporation ponds can, in any case, deal with only relatively small amounts of water, especially as evaporation rates tend to reduce as salinity reaches a high concentration. Such ponds are a hazard, particularly when subject to rainfall or storm water inflows which could cause them to over top or spread. Lateral seepage and the contamination of groundwater and low lying land may be problem in some localities. Such problem exists in SCARPs-VI Rahim Yar Khan area.

7.5 Depletion of On–line Storages

Three storage reservoirs were added to IBIS during 1967-74 as part of the Indus Basin Project. Due to sizeable sediment inflows in the river water, all these storages are losing their capacities. Progressively occurring loss of capacity of the on-line reservoirs, based on conservative projections, is summarized in Table 5.

Table 5. Capacity Loss of on-line Storage Reservoirs

Reservoir	Year of Commissioning	Live Storage Capacity									
		Initial		Year							
				1997		2000		2010		2020	
		BCM	MAF	BCM	MAF	BCM	MAF	BCM	MAF	BCM	MAF
Mangla	1967	6.5	5.3	5.7	4.6	5.5	4.5	5.2	4.2	4.9	4.0
Chashma	1971	0.9	0.7	0.5	0.4	0.4	0.3	0.2	0.2	0.1	0.1
Tarbela	1974	11.9	9.7	10.0	8.2	9.8	8.0	9.0	7.3	8.1	6.6
Total:		19.3	15.7	16.2	13.2	15.7	12.8	14.4	11.7	13.1	10.7

Source: Tarar, 1997.

7.6 Mining of Groundwater

Due to present drought condition groundwater mining has been observed in most of the canal commands. This is very serious as in many areas of Punjab province farmers are using more groundwater than surface water.

7.7 Coordination between Irrigation and Agriculture Departments

The link between the two departments at present is at two levels i.e. at District/Divisional Coordination Committees and at the Provincial Government level. Both these coordination levels are too distantly placed from the farmer. The result is that techniques and the advice provided by the Agricultural Department is independent of the canal water supplies while water rationing by Irrigation Department is independent of advice by the Agriculture Department. The water supplies by Irrigation Department are fixed according to time schedule, irrespective of actual needs of the end users while technical advice rendered by Agriculture Department is general in nature without accounting factual water supplies through canals and other sources. This results in either wastage of water in the form of excess supplies to the farmers who do not need that or under stress conditions to crop where supplies cannot be made in excess due to rigidities of the system. In both ways there is a colossal national loss. This situation demands a very close coordination between the two departments.

7.8 Water Delivery Efficiencies

Efficiency of water use includes operation, conveyance, distribution and field losses. It varies significantly from project to project and depends largely on the soil type that occurs in canal, minor, distributary, watercourse level. The overall irrigation efficiency ranges from 35 to 40 percent. Watercourse average delivery efficiencies, as established by WAPDA survey, are about 55 percent. Based on WAPDA survey results delivery efficiencies for different situations range from 44 to 64 percent.

8. FUTURE CHALLENGES AND OPTIONS

The future challenges and options are briefly given as under:-

8.1 Food Self–Sufficiency

Despite massive investment in irrigation sector and agriculture, Pakistan at present faces food shortages which are likely to become more acute in near future. Scarce water availability and continuous degradation of soil due to waterlogging and salinity, water and wind erosion, sodicity, mutual degradation, flooding and ponding, are some of the major obstacles in the achievement of self-sufficiency.

In order to achieve the envisaged growth target in agriculture, irrigation water requirements as estimated for the year 2000 and 2013 would be 143 and 206 MAF respectively (Table 1).

Water availability for the future has been estimated at 108.7, 107.3 and 126.6 MAF (if 3 dams namely Kalabagh, Basha and Dassu are constructed) in years 2000, 2013 and 2025 respectively. Without requisite water supply, food and fibre deficits would be irrecoverable. Water Sector Investment Planning Study (1990) have reported food, fibre and edible oil shortfall of 23.5 m.tons in year 2000 and 48.5 m.tons in year 2013.

No substantial increase in the water supply is possible in the short run because no dam can be built even if there are no political or other constraints. In other words nothing can be done to reduce water shortages substantially in the near future. Out of 35 to 40 MAF flowing to the Sea and allowing 10 MAF minimal escape below Kotri Barrage for environmental and other abstractions, meager potential of 25 MAF is left for development of surface water resources.

8.2 Need for Environmentally Sustainable Development

It is generally agreed that irrigation and drainage projects which are assisted by adequate levels of Environmental Impact Assessment (EIA) at their initial stages of planning will have greater possibilities of being more sustainable in the long term, and have higher benefit to cost ratios. This is because EIA techniques help to identify and enhance a greater range of possible positive impacts, and provide the opportunity of applying appropriate technological options and mitigatory measures into the design and operation criteria to minimize negative impacts.

Rapid population growth may make it more difficult to address many environmental problems. It is estimated that population of Pakistan, will increase to over 208 million by the year 2025, thus necessitating substantial increases in food, industrial and energy output. Improving the environment for development may make it necessary to raise investment rates in Pakistan by 2-3 percent of GDP. This would enable stabilization of soil conditions, increased protection of forests and natural habitats, improved air and water quality, a doubling of family planning expenditures, sharply improved school enrolment rates for girls, and universal access to clean water.

The primary policy objective must be to achieve sustainable agricultural production. The environment which prompts sustainable agriculture production can be determined on the basis of scientific information required for structural and institutional measures. In the process, a comprehensive EIA, if carried out properly, cannot only identify major areas of environmental damage which may arise from the project, and thus provide the opportunity of adopting necessary measures in the planning, but also greatly assist in developing optimum implementation and operation schedules. The growing recognition of the importance of environmental concerns, the rapid introduction of economic reform programs around the world, and the trend towards democratization and participation in the development process all point in the right direction.

8.3 Redefinition of Public and Private Sector Role

Domestic and global economies are going through vital structural changes with planning objectives, notably as the redefinition of the government and private sector role. The conventional country approaches to planning are reflected in a large public sector investment program, elaborate control on imports and domestic credit, exclusive reliance on the government for the provision of social and physical infrastructure. The recent readjustment in economic management include privatization, decontrol, deregulation, liberalization market orientation, community involvement etc.

These initiatives will alter the nature of planning. In contrast to earlier approaches, which saw the government as the main vehicle for economic change, the new approaches view the government as a catalyst, a manger, and a motivator which should operate through other economic agents such as business, managers, households. This transformation marks a shift from allocative planning to indicative planning and from direct intervention to market signals.

The strategy of irrigation management transfer which is under process, would only be feasible if there is proper and well defined division of roles between the public sector, community groups, and the private sector; and within the public between the Federal, Provincial and local governments. It needs to be supported by a highly decentralized, efficient and participatory institutional apparatus for planning, construction, financing, management and O&M. If decentralization takes place in Pakistan, Government will continue to have a pivotal role, such as development of regulatory framework for surface and groundwater exploitation and information system for natural resource management, etc. In the foreseeable future, O&M of multipurpose reservoirs, provision of off-farm drainage, flood control and management, as well as inter-river and inter-provincial transfer of irrigation water will be managed by the Government.

9. CONCLUSION

Based on the discussion in the previous sections the following can be concluded:

(i) Availability of good quality surface and groundwater is become a serious constraint to achieve food self sufficiency in the country.

(ii) Equitable and reliable availability of irrigation is not ensured at present.

(iii) A number of environmental problems are threatening the sustainability of irrigated agriculture.

(iv) There is a room for improvement in water delivery efficiencies.

(v) River water quality at main points along the Indus are well within acceptable limits for agricultural use.

10. RECOMENDATIONS

In order to achieve the noble goal of sustainability of agriculture, following policies are recommended for implementation:-

i) The quantity of irrigation water shall be increased progressively by additional storage and its quality may be maintained by completing on-going irrigation and drainage projects on priority basis and initiating new irrigation schemes especially in water deficient areas;

ii) An integrated program/system approach for the Basin rather than piece-meal efforts shall be adopted;

iii) In order to increase the national water storage capacity, which at present is 10% of annual river inflows, harnessing of hill torrents, construction of small surface irrigation schemes, check dams, infiltration galleries, diversion weirs, delay action dams, flood irrigation schemes and small and medium size dams in backward areas shall be given top priority;

iv) Water conservation projects such as canal lining, on-farm water management, irrigation system rehabilitation and modernization shall be implemented in an environmentally safe manner. Water use efficiencies shall be increased by adopting new high efficiency technologies.

v) Fertile lands will be protected from waterlogging and salinity by giving priority to disastrous areas having saline groundwater underneath. In drainage sector, mega projects like NDP and RBOD shall be completed and efforts shall be made to devise and implement a drainage plan that can safely pass the drainage effluent to sea without adversely affecting adjoining irrigated areas, lowlands and marshlands;

vi) The application of skimming well technology for exploiting relatively fresh water shall be widely implemented.

vii) The artificial recharge to groundwater to counter intrusion and conservation of water shall be adopted.

viii) Protection of land and infrastructure from recurrent floods and excess rains shall be done by initiating schemes related to flood protection, infrastructure rehabilitation and improvement, flood forecasting and flood warning;

ix) A survey for estimation of private tubewell growth in each canal command needs to be conducted to estimate the quantity of groundwater extraction.

x) Research shall be conducted using Integrated Comprehensive Management approach. It will mainly focus on "Applied" side rather than "Basic" in order to tailor it to the development and make it user oriented. Moreover, investigations shall continue to assess the current status of irrigation and drainage system and devise a sound plan for future.

xi) Salt and drought tolerant crop cultivars shall be evolved to address the new challenges of food and fibre.

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