Proceedings WAMIP-2010
M. S. Rao, et al. (eds)
N.I.H., 2010

Water Management for Food Security in Punjab

J.S. Samra and K.D. Sharma
National Rainfed Area Authority, Planning Commission, New Delhi

INTRODUCTION

Punjab has 20 districts and is predominantly an agrarian state. Green Revolution has changed the overall scenario of agriculture in Punjab. The state's contribution in rice, wheat and cotton production at national level is remarkable. The state of Punjab with only 1.6% of the total geographical area of the country, is contributing 40-50% rice, 60-65% wheat and 20-25% cotton to the central pool since last three decades (NRAA, 2009). About 85% of the state's area is cultivated with cropping intensity of more than 188%. During last 35 years, the area under food grains has increased from 39 lakh ha to 63 lakh ha and the production of rice and wheat has increased from 1.8 to 4 tonnes/ha and 2.2 to 4.5 tonnes/ha, respectively. This change in cropping pattern has tremendously increased irrigation water requirements and irrigated area constitutes about 95% of the cultivated area. The general statistics of the state are depicted in Table 1.

WATER RESOURCES OF PUNJAB

The current status of water resources can be viewed in terms of supplies and demand of water in the state for agricultural and non-agricultural activities (Table 2). Based on an assessment by the Directorate of Water Resources of Irrigation

Table 1. General statistics of the Punjab State, India

Geographical area:	*5.04 m. ha*
Population:	*24.36 million*
Cultivated area:	*4.22 m. ha*
Net irrigated area:	*4.03 (95%)*
Gross Irrigated area:	*5.78 m. ha*
Annual GW availability:	*23.78 BCM*
State of GW Development:	*145%*
Irrigation by GW:	*72.44%*
Cropping Intensity:	*188%*
Fertilizer use:	*210 Kg/ ha.*
Yield of Rice	*4 t/ ha*
Yield of Wheat	*4.5 t/ ha*
Yield of Coarse cereals	*3.3 t/ ha*
Yield of Oilseeds	*1.3 t/ ha*

Source: Agricultural Statistics at a Glance, 2009

Table 2. Water resources of Punjab

Source	Coverage
Canal	1.10 m ha
Tube Wells	2.92 m ha
Others	0.10 m ha
Total	4.03 m ha

Department of Punjab, total surface water available at different head-works is about 17.9 billion m^3. Of these, 14.5 billion m^3 is available at the outlet. The ground water contribution is 16.8 billion m^3 thus making the total availability of water at 31.3 billion m^3. The crop water demand has been worked out as 44.0 billion m^3, thus leaving an annual deficit of 12.7 billion m^3. In order to meet the requirements/demand, ground water is being over-exploited using shallow and deep tube-wells in the state, the number of which has swelled from a mere 0.192 million in 1970 to 1.193 million at present in the state. The latest study of ground water balance estimates (CGWB, 2006) shows that out of 137 development blocks, 103 (75%) fall in 'over-exploited' category having ground water extraction more than 100% of annual replenishment, 5 are classified as critical with stage of development between 90-100%, 4 are 'Semi Critical' having stage of development between 70 and 90% and only 25 (18%) in 'Safe' category having ground water draft less than 70% of annual recharge. Block Nihalsinghwala in Moga district has the maximum stage of development with more than 200%. Safe blocks lie in south-west Punjab but the ground water is of poor quality and in Kandi area where extraction is restricted due to deeper ground water aquifers.

The water level data (monitored by Directorate of Water Resources and Environment, Punjab) also reveals that in 44% of the state's geographical area, water table is beyond the critical depth of 10 m. The area having water table depth below 10 m range has increased from a mere 3% in 1973 to 53% in 2000. The long term data for the period 1984-2002 reveals that water table has fallen in about 80% of the state's geographical area. Up to 1995, the average fall of water table in Punjab was about 23cm/year which during the next 6 years (1997-2003) increased to 53 cm/year and is currently about 70 cm/year.

Considering the present trend of fall in water table, the future projections are quite disturbing. It is estimated that by the year 2020, more than 30% additional area of the state would be added to the area where water table depth is already beyond the critical depth of 10 m. As compared to the year 2001, the water table in central Punjab will fall in 34% area by 2010 and by the year 2020, entire central Punjab will have water table depth beyond 14 m (NRAA, 2009).

REASONS FOR DECLINING TREND OF GROUND WATER TABLE

The present ground water scenario is because of the following reasons.

- **Change in cropping pattern.** The Punjab farmers shifted from low water consuming crops to high water requiring paddy crop irrespective of the soil and climatic conditions. There has been a drastic increase in area under paddy from 4 lakh ha in 1971 to 26 lakh ha in 2004. Paddy consumes about 62% and wheat about 20% of the total irrigation requirement of the State. The water intake of paddy crop is the maximum which is about 3 cubic metres/kg of output.
- **Increase in area under irrigation.** Net area under irrigation has increased from 70% in 1970-71 to 95% in 2007-08. Also, there is an increase in cropping intensity from 124 to 188% resulting in an increased abstraction of ground water over the years. The net area

irrigated by canals has decreased from 45% in 1970-71 to only 25% in 2001-02 which indicates that dependency on ground water has increased tremendously to meet food production targets.

- **Increase in number of tube-wells.** The number of tube-wells has increased from 0.192 million in 1971 to 1.1 93 million (more than 6 times) in 2006 (NAAS, 2009). This has resulted in over-exploitation of ground water.

- **Lack of proper planning of systematic ground water extraction.** Over-exploitation of ground water has been taking place to meet the increased demand of irrigation water for crop production, and industrial and domestic sectors because of property-based rights.

- **Change in rainfall pattern.** There has been a decline in the overall rainfall in the state during the *kharif* season. The number of rainfall events has been reduced with more high intensity and short duration storms (which generate more surface run-off) rather than more numbers of low intensity long duration rainfall which induce increased recharge.

  The net result has been that natural recharge has decreased.

- **Overall increase in water demand.** To meet the increasing demand of industrial and domestic sectors, ground water extraction has been on the rise.

Action Plan for Efficient Water Management

The water resources in the state of Punjab can be managed by saving irrigation water by using water saving techniques, adoption of resource conservation technologies, crop diversification, and by augmenting the ground water resources through artificial recharge techniques. These recommendations can be implemented in a phased manner for concrete outcomes.

- **Water saving techniques**. Average efficiency of irrigation systems, at present, is very low ranging from 30 to 40%. Water is lost during conveyance through seepage from main canal, branches, distributaries, minors, water courses and field channels. However, return flows are recovered by tube-wells.

- **Lining of conveyance.** Lining is an effective way of minimizing conveyance losses. Conveyance losses can also be avoided using underground pipeline especially in saline aquifers where recovery through tube-wells is not feasible.

- **Method and amount of irrigation.** Proper selection of an irrigation method for a particular crop is very important to achieve higher application efficiency. For example, the replacement of border method of irrigation with furrow method of irrigation in wide-row crops like cotton, sunflower and maize can save about 30% water. For efficient application of irrigation water the optimum plot size depending on soil types, field slopes and stream sizes should be adopted.

Action Plan for Rice-Wheat Cropping System

- **Efficient Irrigation scheduling for rice.** Intermittent irrigation in paddy i.e. 15 days ponding followed by 2 days of drying can result in 25% saving of water. Shifting the date of transplanting of paddy from first week of May to third week of June checks the water table decline by 17 cm/year without any adverse effect on the crop yield. State Government has already introduced legislation to this effect.

- **Dike height of paddy fields.** For conservation of rain water, the optimum effective field bund height in paddy should be 15, 17.5 and 22.5 cm for light, medium and heavy soils respectively.

- **Participatory approach through resource conservation technologies (RCT).**

  Adopting Resource Conservation Technologies *(RCT)* are quite impressive in rice-wheat cropping system for efficient water management and should therefore be encouraged for adoption by farmers.

- **Zero tillage technology**. Studies have revealed that use of zero-till seed drill on one sq km of land is estimated to save water and diesel approximately by 0.1 and 0.001 million m^3, respectively. Area under rice-wheat cropping system is increasing at a faster rate in Punjab. More emphasis is required to encourage use of zero-till seed drill throughout the whole tract of rice-wheat system. Zero tillage allows rice-wheat growing farmers to sow wheat immediately after rice harvest, so the crop is matured and fills the grain before the onset of pre-monsoon hot weather. As average temperature in the region may rise because of climate change, early sowing will become even more important for wheat.

- **Laser-aided land levelling.** Laser levelling of uneven fields reduces water use allowing the crop to grow in limited water conditions. Precision laser land levelling technology saves costly inputs like fertilizers, improves crop stand, and increases yield by about 15%. Laser levelling saves irrigation water by about 25% and reduces labour cost. Several other benefits such as operational efficiency, weed control efficiency and water use efficiency have also been reported due to laser-aided land levelling. Custom hiring of the laser-aided land levelling should be encouraged for higher water productivity.

- **Green manuring.** Growing of quick growing *Susbenia* along with rice, which have many advantages like weed control and better nutrient management, can also be implemented in phased manner in direct seeded rice under rice-wheat cropping system.

- **Bed planting.** Bed planting of wheat saves about 18 to 25 % of water as compared to the conventionally tilled wheat.

- **Mulching.** Application of straw mulch improves the water use efficiency and helps in water saving by reducing the ET losses. It also increases the yield of a number of field crops during summer months. A few reports on the effect of mulching on water use in rice-wheat system reveal that mulching helps in saving of water in the range of 25 to100 mm resulting in less number of irrigations and reducing irrigation time by about 17%.

- **New planting techniques of rice.** New planting techniques like System for Rice Intensification (SRI), aerobic rice and direct seeded rice have advantage of faster and easier planting, reduced labour requirement and drudgery with earlier crop maturity by 7-10 days, better efficient water use and high tolerance to water deficiency, less methane emission and higher income due to lower cost of production. These technologies can be implemented in a phased manner to reduce the water requirement and for better input utilization.

- **Replacement of long duration crop varieties.** Long duration varieties of rice require higher amount of water. Emphasis needs to be given on short duration varieties and superior quality basmati, having lower water requirement.

Action plan for Cotton-Wheat Cropping System Cotton is the most important cash crop of Punjab. This is the backbone of the farmers of south-western region of Punjab. During 2008 the crop was sown on an area of 5.27 lakh ha with productivity of 737 kg/ha and production of 22.85 lakh bales

(Anonymous, 2009). The cotton belt of Punjab (south-western districts) differs from other regions of the state of Punjab with respect to low rainfall (less than 400 mm/ year), low and erratic canal water supply, sandy soils, saline ground water, and high temperature coupled with strong stormy wind during summer months. Due to scarcity of good quality canal water and poor quality of ground water, the productivity of cotton gets affected. So, it becomes imperative to give impetus for development of improved water saving technologies to achieve higher productivity in a sustainable manner. Following action plan is suggested for efficient utilization of surface water in conjunction with poor quality ground water which has positive effect on the adoption of the technology at farmers' field:

- **Ridge planting of cotton.** Experiments conducted over a period of 6 years revealed that ridge planting of cotton in south-western Punjab saved 33% water compared to conventional planting (flat sowing) and farmers of this region have been benefited by irrigating 30% more area with the same quantity of water.

- **Apply first irrigation at 6 Weeks After Sowing (WAS).** Experimentation of last 5 years revealed that there was consistently higher seed cotton yield when first irrigation was applied at 6 WAS instead of earlier recommendation of 4 WAS. Based on data of five years, the delay of first irrigation from 4 WAS to 6 WAS increased seed cotton yield by 208 kg/ha (16% higher). This practice led to significant reduction in flower shedding along with deep penetration of roots and more root biomass. There is a spectacular increase in water use efficiency with delay in first irrigation.
- **Conjunctive use of saline ground water and canal water.** In south-western Punjab ground water is saline which could be utilized in conjunction with canal water for cotton in cotton-wheat cropping system. Salinity tolerant crop varieties can be promoted.

- **Drip irrigation in cotton.** In areas, particularly in tail end of the canals, there is a scarcity of water and cultivation of cotton under drip irrigation is a viable proposition in these regions for higher productivity. Action should be initiated for popularizing installation of drip irrigation in the areas of scarcity for bumper cotton production.

CROP DIVERSIFICATION

Replacing rice with less water guzzling crops such as vegetables, soybean, groundnut, pulses, etc. could save substantial quantities of water (Table 3). This has been recommended by the *Johal Committee* on crop diversification but needs to be implemented in letter and spirit to retrieve the situation on water front. Protected net or poly-house cultivation of vegetables can save large amount of water and multiply farm income. However, segregation, processing, branding and marketing of value added products is necessary.

Area under horticultural crops under National Horticultural Missin is also increasing in the state and emphasis should be given for introduction of modern techniques of water application. Different water saving technologies for vegetables and floriculture production like drip-fertigation, poly-

Table 3. Crop diversification for replacement of rice with other crops

Crop	Area (lakh ha)	Water saved over rice (million m^3)
Maize	2.5	325
Groundnut	0.5	115
Soybean	0.5	65
Pulses	0.5	150

house, net-house cultivation for off-season and pesticide free vegetables should be encouraged in a phased manner.

Two fruit processing plants (capacity: 10 tonnes/h), which have been established at Abohar and Hosiarpur, should be utilized to their full capacity. Also, the production of fruits and vegetables should be planned in such a manner that vegetable glut should not happen and farmers should get the desired profits.

ACTION PLAN FOR AUGMENTING WATER RESOURCES

The Kandi area experiences more than 1,000 mm of annual rainfall, out of which 40% goes as runoff during the rainy season. There are about 120 small Water Harvesting Structures (WHS) in the Shivaliks' foothills under different watershed programmes. It has been conclusively established that due to the impact of these structures, the water table which was falling in Hoshiarpur district, has been experiencing an average increase of 6 cm/ year.

Further, artificial ground water recharge techniques such as constructing check dams on Ephemeral streams coupled with infiltration galleries to a tube well for artificial ground water recharge in *Kandi* area of Punjab have ample scope and should be implemented.

Increasing ground water recharge. A large number of studies in recent years bring out the possibilities of promoting greater recharge of aquifers with surplus runoff available during the rainy season through spreading or by injection through wells. The available network of surface drains can be used for artificial recharge by installing series of recharge shafts in drains which are underlain by comparatively more impervious strata.

- **Roof top rainwater harvesting.** Roof top rainwater is the purest form of water before it joins the surface runoff. If this could be tapped for artificial ground water recharge, this would help in checking the ground water decline besides improving the quality of ground water, reduce the load on sewage system, save the roads and streets from possible damage and health hazards.

- **Renovation of village ponds/abandoned tube-wells for recharge.** There are about13,000 village ponds out of a total of 23,000 in Punjab which can be brought into use for providing irrigation or recharging. The water stored therein would thus reduce the ground water withdrawal by about 6 cm/year. Many farmers have shifted from centrifugal pumps to submersible pumps. The pits of centrifugal pumps can be used for ground water recharging.

ACTION PLAN TO CONTROL DEMAND OF WATER

There is a need to pay more attention towards controlling the demand of water in the agriculture sector by adopting following measures:

- To discourage paddy cultivation, alternate crops be covered under Minimum Support Price (MSP) which would help in crop diversification.

- Modern pressurized irrigation methods such as sprinkler and drip irrigation along with closed-pipe conveyance system, instead of water courses and horticulture need be encouraged.

- Industry with heavy demand for water may be discouraged and recycling of water be made mandatory.

- Electricity subsidy should not be open ended. It should be restricted either on time of application or area basis in such a way that farmers opt for efficiency.

- 10% area of cultivable land of farmers having large land holdings may be covered under

forestry or horticulture to improve environment.

- Depth of tube-wells may be restricted or horsepower of tube-wells may be limited to 10 hp so that deeper aquifers may not be tapped (beyond first two aquifers). Only government should tap deeper aquifers and provide controlled water supply.
- Modern techniques of paddy cultivation such as SRI and dry seeding of rice may be encouraged as these do not require flooding of the fields.
- **Action Plan for Conservation of Water** Following conservation techniques should be promoted which can save a large quantity of ground water thereby reducing the trend of its decline.
- Practicing recommended irrigation scheduling.
- Mass awareness programme to acquaint people with need for sustainable irrigation management and problems related to water resources be launched through Participatory Irrigation Management (PIM) and Water Users' Associations (WUAs).
- Zero tillage practice, precision land levelling and straw mulching need to be encouraged
- Install energy efficient pumps and ensure regular supply of power to tube-wells to decrease wastage of water.
- Protection of wetlands and village ponds.
- Conjunctive use of saline water with fresh water.
- Recycling of water and proper treatment of wastewater to reduce pollution be made mandatory for industries with heavy demand and ground water extraction needs to be limited with metered supplies in order to promote multiple uses of water.
- **Creation of data base:** A sound data base is an essential pre-requisite in water resource management. Periodic monitoring, analysis, documentation and dissemination of this information will help in proper water resource utilization, framing policy guidelines and planning management strategies.

➢ The relevant information on soil characteristics, land use, cropping pattern, crop productivity, water table, etc. should be collected and compiled.

➢ Dependable data, based on ago-climatic conditions of a region, are needed on water resources availability, temporal release of water and reliability of water supply from reservoirs, ground water status in terms of recharge, extraction and quality, areas under irrigation and quality of irrigation service.

➢ Information needs to be compiled on possibilities of using waste/recycled waters, water use pattern, efficiency constraints, water induced environmental socio-economic and institutional aspects.

➢ Natural resources like water and soil always have a spatial dimension overriding them. Therefore, GIS is an essential requirement for efficient and quality water resources research.

ACTION PLAN FOR SOUTH-WEST PUNJAB WITH WATER-LOGGING AND SOIL SALINITY

(i) Preventive measures.

- Propagating efficient 'on-farm water management' practices including modern methods of irrigation (sprinkler, drip, furrow, etc.), irrigation scheduling depending on crop, soil type, water supply, water quality and water table depth.
- Effective and efficient lining of remaining canals and water courses and their periodic maintenance for checking seepage losses.

- Reduction in canal water supply so as to encourage farmers to use saline groundwater as such or in conjunction with canal water for irrigating salinity tolerant crops. The canal water thus saved should be diverted to water deficit areas and lift canal systems.

- Constructing balancing/storage reservoirs at appropriate sites in canal command areas for storage of surplus canal and flood water for its subsequent use. Construction of diversion ditch/drain at the upstream edge of the area to be protected. Installation and operation of row of tube wells to intercept ground water and reconstruction of the natural drain be encouraged.

- Maximizing conjunctive use of saline water with canal water in the problem areas for raising agro-horticulture, agro-forestry, plantation and grasses. The agro-climatic conditions in the state are favourable to permit use of poor quality ground water directly in sandy or sandy loam soils or after mixing with canal waters in all types of soils for tolerant and semi-tolerant crops.

(ii) Curative measures

- ***Subsurface drainage system.*** The only solution to control water-logging and related soil salinization problems is the improved water table management practices. Studies have revealed that provision of suitable drainage systems in irrigated areas have generated positive socio-economic impacts including increase in crop yields (20-50%), increase in cropping intensity (30-60%), increase in employment, reduced migration to urban areas, increase in land value and development of agro-industries. The four most common techniques used to drain excess water are: surface drainage, subsurface (horizontal) drainage, vertical drainage and bio-drainage.

- ***Integrated drainage.*** There is a need to integrate subsurface drainage system with bio-drainage practices and introducing saline water fish culture in disposal sinks. The combination of subsurface drainage system with tree belts with higher water intake can reduce the drain water volumes as well as help in reducing the cost of drainage system.

The evaporation-cum-fish culture ponds and agro-forestry can act as disposal sinks for drainage effluent. The controlled drainage and conjunctive use can be practiced in drainage areas to improve water productivity further. Thus farming system approach for integrated drainage system management should be encouraged.

DISTRICT-WISE ACTION PLAN FOR THE STATE

Some suggested cropping systems along with corresponding land development, farming practices and agronomic measures suitable for different districts in the State of Punjab are given in Table 4.

REFERENCES

Anonymous. 2009. *Agricultural Statistics at a Glance*. Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.

CGWB. 2006. *Dynamic Ground Water Resources of India.* Central Ground Water Board, Ministry of Water Resources, New Delhi.

NAAS. 2009. *State of Indian Agriculture.* National Academy of Agricultural Sciences, New Delhi.

NRAA. 2009. *Food Security, Water and Energy Nexus.* Position Paper 3. National Rainfed Area Authority, New Delhi.

Table 4. District-wise action plan for the State of Punjab

Operational area (Districts)	Crop/ cropping System	Land Development	Planting method	Irrigation method	Conservation technology
	Cotton-wheat cropping system				
Bhatinda, Mansa, Muktsar, Ferozpur, Faridkot	Cotton	Laser leveling		Surface	
		-	FIRBS (Furrow Irrigation and Raised Bed System		Mulching
		-	-	Drip and mini sprinkler	Mulching
	Wheat	Laser levelling	-	Surface	-
		Sub-surface/ integrated drainage	Bed Planting	Surface	Cyclic & conjunctive use of saline and canal water
	Rice-wheat cropping system				
Amritsar, Sangrur, Patiala, Ropar, Moga, Kapurthala, Ludhiana, Fatehgarh, Jalandhar, Ferozepur, Gurdaspur	Rice	Laser levelling	-	Surface	SRI, DSR, Aerobic
	Rice	Laser levelling	-	Surface	Mechanical transplanting
	Wheat	Laser levelling	-	Surface	Zero-tillage
		-	FIRBS	Mini sprinkler	Zero-tillage
		-	Bed planting	Surface, mini-sprinkler	Zero-tillage
	Sugarcane-wheat cropping system				
Sangrur, Patiala, Nawasahar, Kapurtahala, Jalandhar, Ferozepur, Gurdaspur	Sugarcane	-	Pit plantation	Drip,	Intercropping with onion, garlic, raya, wheat
	Sugarcane	Laser levelling	-	Surface	
	Sugarcane	-	FIRBS	Drip, Sprinkler, Rain gun	
	Kharif pulses – Raya / wheat cropping system				
Ferozepur, Gurdaspur	Kharif pulses	Laser leveling	Ridger seeder	Surface	-

Hoshiarpur	Raya / wheat		Sowing FIRBS		
		-	Ridger Seeder sowing	Conserve moisture, Furrow irrigation, Rain gun	Mulching
	Vegetable crops				
Sangrur, Patyiala, Moga, Kapurthala, Ludhiana, Fatehgarh, Ferozepur, Hoshiarpur	Vegetable crops	Laser leveling	-	-	Mulching
	Vegetable crops	Laser leveling	Bed planting	-	-
	Vegetable crops	-	-	Drip & Micro-sprinkler	Mulching
	Horticultural crops				
Patiala, Fatehgarh, Jalandhar, Ferozepur, Muktsar, Bhatinda, Hoshiarpur	Fruit crops	Laser levelling	Sloping towards tree	Surface	Intercropping
	Fruit crops	-	-	Drip	Mulching
	Fruit crops	-	-	Drip integrated with Canal water harvesting in secondary reservoir	Mulching