

**DEMOGRAPHIC INFLUENCES ON LAND AND WATER
RESOURCES AND FOOD SUSTAINABILITY CONCERNS:
VISION 2025**

by

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ABSTRACT

Population of Punjab province is higher to any province of the country. The annual growth rate of 1998 census works out to be 2.64 and 2.61% for Punjab and Pakistan, respectively. These growth rates have been used for projecting the population trends in 2025 and 2050. Population in Punjab projects to 148.78 and 285.41 millions in 2025 and 2050 against that of Pakistan corresponding to 261.82 and 498.59 millions.

This demographic pressure definitely will affect our land and water resources. Estimation of shrinking land and surface water resources in context of expanding population reveals that per capita surface water availability has reduced from 0.835 AF in 1992-93 to 0.681 AF in 1999-2000, when total canal withdrawals in Punjab did not exceed to 52.56 and 52.868 MAF in 1992-93 and 1999-2000 against a population pressure of 62.972 and 77.560 millions. Similarly, per capita land out of total geographical area of Punjab (20.63 m ha) decreased from 0.328 ha in 1992-93 to 0.280 ha in 1998, while based on total agricultural area (14.47 m ha) about an area of 0.230 ha per capita decreased from 1992-93 to 0.197 ha in 1998-99. Corresponding to 0.230 ha per capita land in 1992-93 and 0.197 ha per capita in 1998-99 the per capita canal withdrawals share tuned to 0.835 and 0.733 AF. The estimation for the projected population points out that per capita agricultural land would decrease to 0.097 ha for a provincial population of 148.782 millions in 2025.

The increasing demographic pressure on land and water availability in Punjab has yielded to some potential food sustainability concerns. It is estimated that wheat and rice grain requirement would increase to 17.85 and 5.95 million tons in 2025 against existing level of 8.84 and 2.9 million ton in 1998. The wheat grain and rice requirements on per capita energy requirement basis (930,750 calories per year per capita) would become to 34.25 and 11.42 millions tons in 2050 against the projected population of the Punjab province (285.41 millions). Similarly, sugar requirement may increase to 5.98 million tons in 2050 from 3.14 millions tons in 2025.

The projected land and water requirements in Punjab during 2025 for wheat, rice and sugarcane would correspond to 7.23, 3.77 and 0.41 m ha with farmgate water requirement of 17.87, 48.91 and 5.91 MAF (at the corresponding present average crop yields of 2.469, 1.58 and 43.5 ton per hectares). The area and farmgate water requirement for wheat, rice and sugarcane can be curtailed to 4.82, 2.51 and 0.27 m ha and to 11.91, 32.56 and 3.89 MAF with the 50% increase in the existing average yield of crops. Similarly to meet wheat (34.25), rice (11.42 mt) and sugar (4.55 mt) requirements of the projected population in 2050 an area of 13.87, 7.23 and 0.79 m ha would be required with the corresponding farmgate water availability of 34.27, 93.80 and 11.38 MAF at the present average yield value. This seems highlights the need to manage the resources in this context of high water requirement. The 50% increase in yield of crops and check over population can solve the problem.

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The paper accentuates the need of wise strategic planning to meet with the food sustainability issues. It is worked out that this issue if not tackled seriously will lead to a complete famine in the coming times. Point may come when all the culturable waste and water storage facilities may not tackle the negative impact of ever increasing population pressure over the province and country as a whole. The paper discusses three main feasibilities to address the food insecurity risk namely: i) Increasing average yield per unit land, ii) bringing more area under plough and iii) exercising control over urbanization and population. The paper suggests an integrated approach that is span over all the feasibilities mentioned to mitigate the food insecurity. The paper also points out that it is high time to think of widening gap between food production and consumption in context of demographic pressure in the coming time. It is warned that proper strategies if not adopted or policies not framed, the food security would be at the highest risk. It will be wise to review the today's situations and plan right now for tomorrow. It is also the high time to use tomorrow's technology today to combat with the coming challenges in the future.

INTRODUCTION

Population growth rate of the country is about 2.7 percent against the agriculture growth rate of 6.1 percent in 1999-2000. It declined to negative growth rate of 2.5 percent in 2000-01. The experts report that agricultural growth rate must be maintained sufficiently above the annual population growth rate (Khan, 2002). This is important to meet the food requirements and to have reasonable export surplus to sustain the agro-based industry of the province and country as a whole. The present population of the country may elevate to 221 millions in 2025 (Halcrow and ACE, 2002). These figures may vary from those mentioned in this text or projected by some others. The projection in this text is based on the average of all the censuses with standard deviation values included in growth rate.

The control over population seems difficult in future due to many reasons described in this text. It is highlighted that scenario in 2025 in context of food, land and water resources is perhaps not that horrible as it would be in 2050. The policy makers must seriously consider of taking most effective measures to exercise to control over birth rate through awareness and workable strategies. The population if not controlled will add burden to the national economy and increase the food insecurity risk in future.

Our land and water resources are shrinking with the ever increasing population pressure. Consequent upon the increasing populating pressure, per capital agricultural land and water availability for agricultural use is declining to a terrible limit. The decreasing trends in land and water resources necessitate keeping a vigilant eye on the emerging food requirements with the expanding population. We should explore every feasibility to combat with the increasing risk to food security. With this situation in view the in hand paper has been designed to :

- highlight the pressure on land and water resources
- project the importance of soil, crop and water resource base management
- to figure out the projected food needs for the ever increasing population
- predict the need of time rate increase in the land and water resources
- provide food for thought to policy makers and create awareness among masses.

DATA SOURCE AND ANALYSIS

A literature survey was conducted to support the concept of demographic influences on the land and water resources. The data sources used are:

Sr. No.	Data Source	Information
i	Halcrow and ACE	For food projections
ii	Punjab Irrigation & Power Dept. Lahore (Regulation Wing)	Water Flows
iii	Directorate of Crop Reporting Service Lahore	Geographical area and cropping patterns
iv	Directorate General of Agriculture Davis Road, Lahore	Average crop yields
v	MINIFA	Crop irrigation requirement
vi	Newspapers and research papers as referenced in the relevant text	Miscellaneous

RESULTS AND DISCUSSION

Demographic Profile

Population of Punjab province is higher to any province of the country (Sub fig of Fig 1). The previous censuses in Punjab give the annual population growth rate of 2.17, 3.41, 2.74 and 2.64 percent in 1951/1961, 1961/1972, 1972/1981 and 1981/1998 periods. The average annual growth rate thus comes to $2.74 \pm 0.51\%$. It varies from 2.17 to 3.41%. Annual growth rate for Pakistan recorded during previous censuses are 2.3, 3.69, 3.06 and 2.61 % with an average of 2.91 ± 0.60 . Calculation for future population based on the annual growth rate of 1998 is given in Table 1.

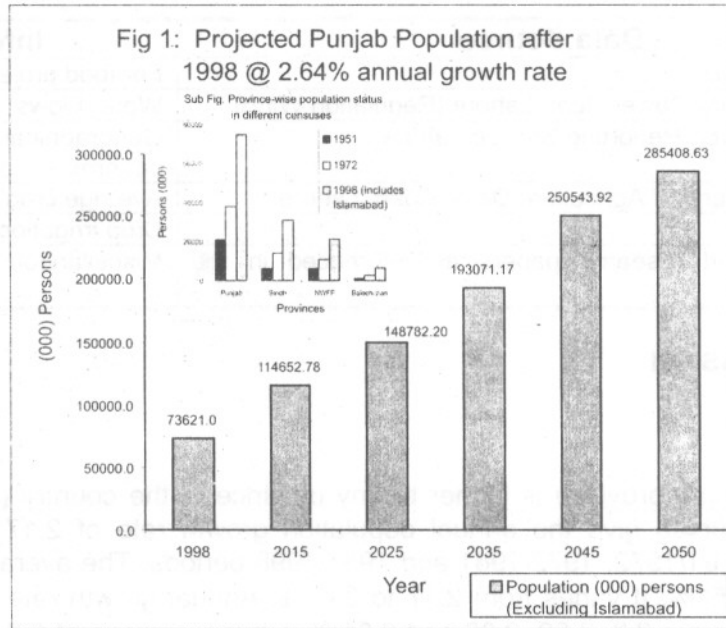
Table 1: Projected population of Punjab and Pakistan (2000 to 2050)

Parameter	1998	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Projected estimate (2000-50)												
Population (000'persons)												
Punjab	73621.0	77559.5	88352.3	100647.1	114652.7	130607.4	148782.2	169486.1	193071.1	219938.2	250543.9	285408.6
Pakistan	130580.0	137485.2	156388.3	177890.5	202349.1	230170.5	261817.2	297815.0	338762.3	385339.5	438320.6	498586.3

Population estimates are based on annual growth rate of 2.64% for Punjab and 2.61% for Pakistan

This indicates that the population of Punjab will increase from the 1998 figure of 73621 thousands to 148782.2 thousands in 2025 (Fig 1) that is, the total population would double by the end of first quarter of the century. The population in Punjab would increase to 285408.6 thousands in 2050, which is 3.88 times increase over base year (1998). It will jump from 130580 thousands in 1998 to 261817.2 thousands in 2025, almost two times increase at the average growth rate of 2.61 at Pakistan level.

Some people estimate that population in Punjab would tripple by the end of 2023 (PMRP, 1995) assuming 3.2% as annual growth rate. The experts report that our agriculture is dwindling as water shortage has created many problems for the growers. Besides harvesting record yield in the recent years, the food security will remain a question mark. The increase in harvests is not compatible with the rate at which the population increases.



LAND AND OVERALL WATER SCARCITY RISK: DEMOGRAPHIC INFLUENCES

The land and water act as major resources for crop production. Unluckily both the resources are shrinking in view of expanding population. The following section the need for sustainable soil and water resource base management.

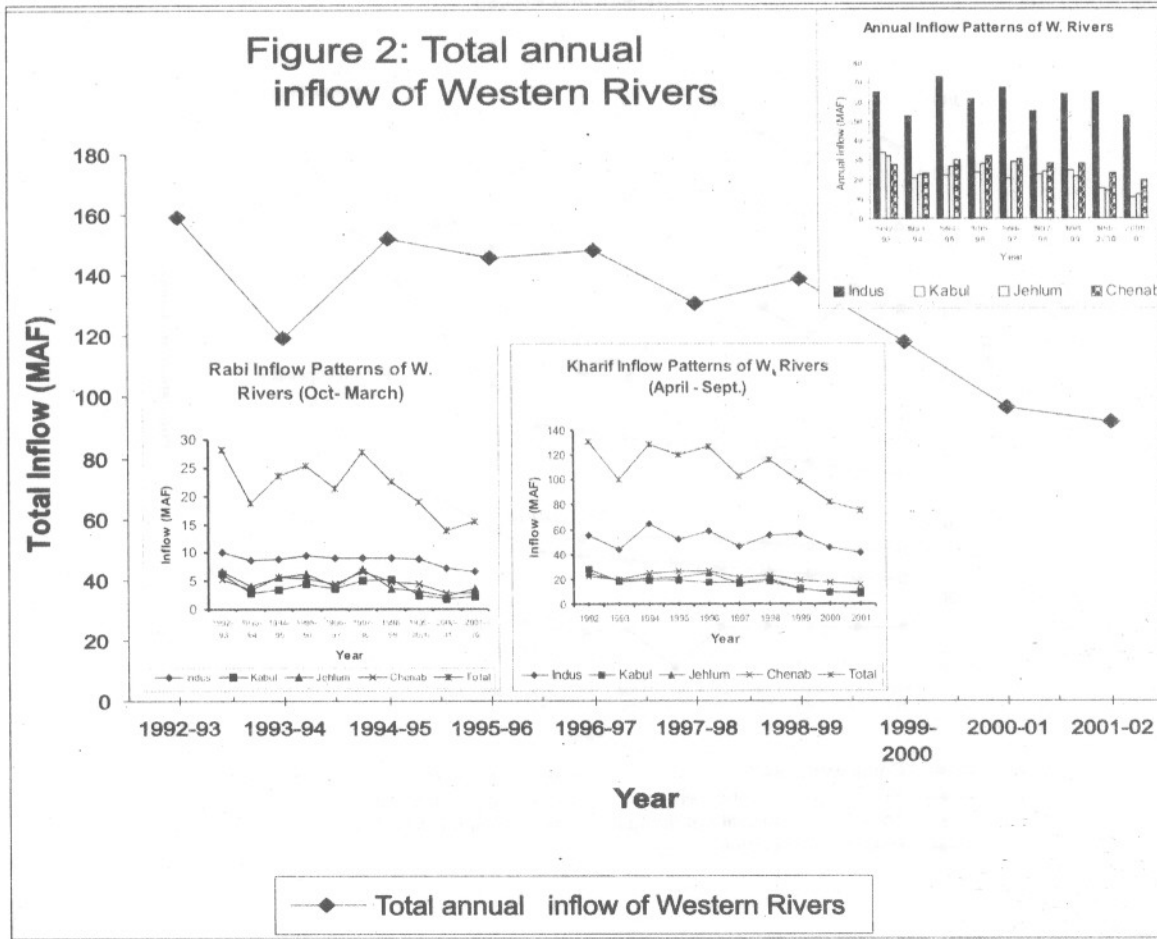
Fluctuations in River Flow Patterns

Water is the key factor in the process of food production. Any fluctuation in this factor may adversely affect food production. The water resources are being affected seriously. Let us analyze the situation prevailing in our rivers from the last decade of the years and foresee the threats to food production.

A temporal variation has been noted in river flow patterns from 1992-93 to 2001-2002. Inflow in Indus River in *Kharif* varied from 41.47 to 55.22 MAF during 1992 to 2001 with average *Kharif* inflow (1992-2001) of 51.99 ± 7.31 MAF. Similarly data of ten years for *Kharif* season years indicate a mean inflow of 17.04 ± 5.40 , 17.64 ± 5.99 and 21.61 ± 3.64 MAF in Kabul, Jehlum and Chenab River. The mean inflow in *Rabi* season corresponding to Indus, Kabul, Jehlum and Chenab was 8.65 ± 1.01 , 3.73 ± 1.46 , 4.64 ± 1.63 and 4.55 ± 1.24 MAF. The total inflow (1992-93 to 2001-02) of the western rivers during *Rabi* and *Kharif* averaged to 21.57 ± 4.85 and 108.27 ± 19.40 MAF. Apart from this period under discussion (1992-93 to 2001-02) the annual flows of Western rivers at rim station on post Tarbela period (1976 to 2000) have been averaged to 25.72 MAF in *Rabi* (with minimum and maximum value of 20.75 and 30.57 MAF) and 117.46 MAF in *Kharif* with minimum and maximum flow of 79.10 and 141.53 MAF. Data of Water Resource Management Directorate, WAPDA for post Tarbela period (1976-2000) on annual flows gave an average value of 143.18 MAF with minimum and maximum flows of 99.85 and 172.10 MAF. So average *Kharif* inflow has dropped from 117.46 MAF (for the period 1976 to 2000) to 108.27 MAF (for period of 1992-93 to 2001-02).

The data displayed via Fig. 2 point out that total inflow during *Kharif* season fell from 116.05 MAF in 1998 to 75.78 MAF in 2001, while total inflow dropped from 22.55 MAF in 1998-99 to 15.45 MAF in *Rabi* 2001-02. Total water inflow during *Kharif* 2001 and *Rabi* 2001-02 decreased by 42.13 and

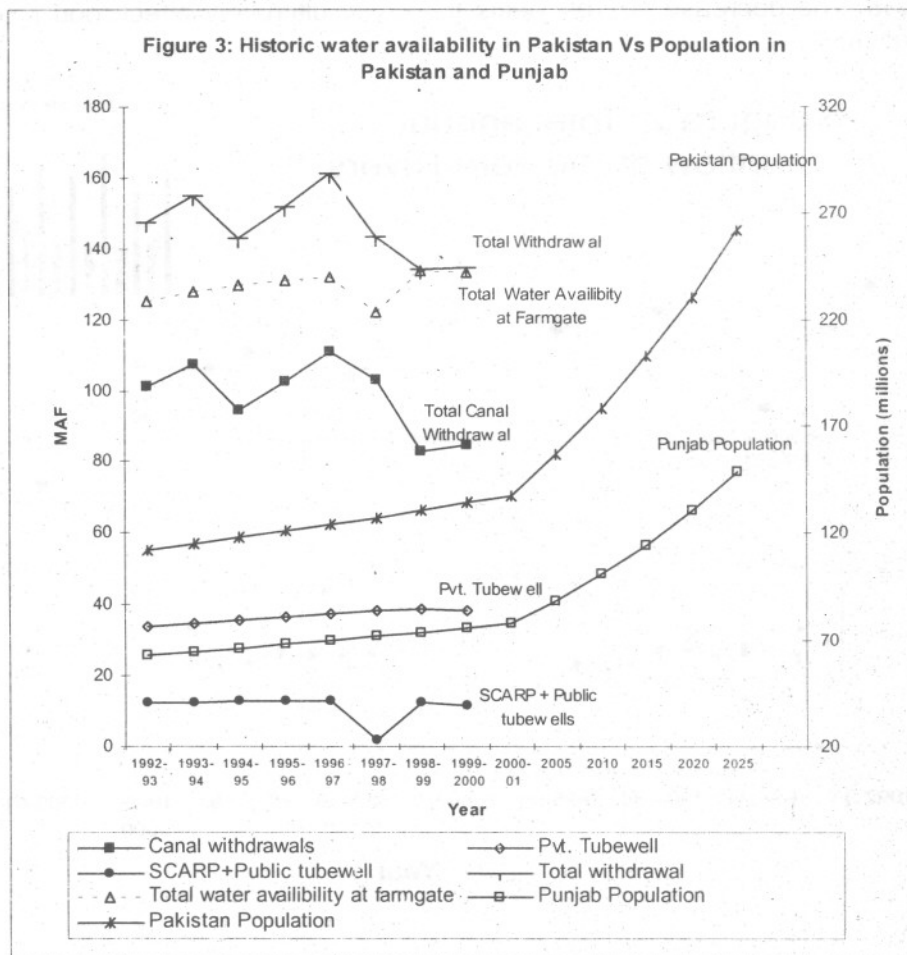
45.12 percent, respectively. It is also evident from the main Fig.2 that total inflow of western rivers fell from 159.10 MAF in 1992-93 to 91.23 MAF in 2001-02. This 42.65 percent decrease in total inflow (including Kabul) by the end of 2001-02 is alarming. This indicates that irrigation system is subject to serious water crises, which definitely may influence the crop yield due to water stress during critical crop growth stages. The decrease in crop yields then may ultimately affect food production for ever increasing population.



The eastern rivers became dry after Indus Water Treaty with India. The eastern rivers then were linked with the western rivers through a network of link canals. Thus, the eastern rivers depend upon the flows in western rivers. As the western rivers suffered acute shortage during drought period, the flow in eastern rivers also suffered badly. According to data available from 1990-91 to 2000-01 on flow of eastern rivers at rim station, the *Kharif* inflows fell from 7.94 MAF in 1990-91 and 13.77 MAF during 1995-96 to 0.87 MAF in 2000-01. On the average (1990-91 to 2000-01), eastern rivers receive 6.85 MAF inflow during *Kharif* and 1.56 MAF in *Rabi* with average annual total inflow of 8.41 MAF. This system also received a serious setback during water crises. Seen in the background of current shortages and rapidly increasing future demands, the experts have foreseen that this situation would simply be unsustainable for the agriculture and our national economy (Haq *et al.*, 1997). The aforementioned deficits reveal that variable inflow patterns of rivers have affected the canal withdrawals in the Punjab province

Soil and Water Availability : Per Capita Trends

It is evident from Fig 3 that total withdrawal in Pakistan and total water availability at farm gate (from all sources) is not in consistence with population increases. The total withdrawals supercede to some extent by the year 1998-99, while the declining curves extrapolation after the year, 1999-2000 intercepts the line drawn for the projected population of the country.

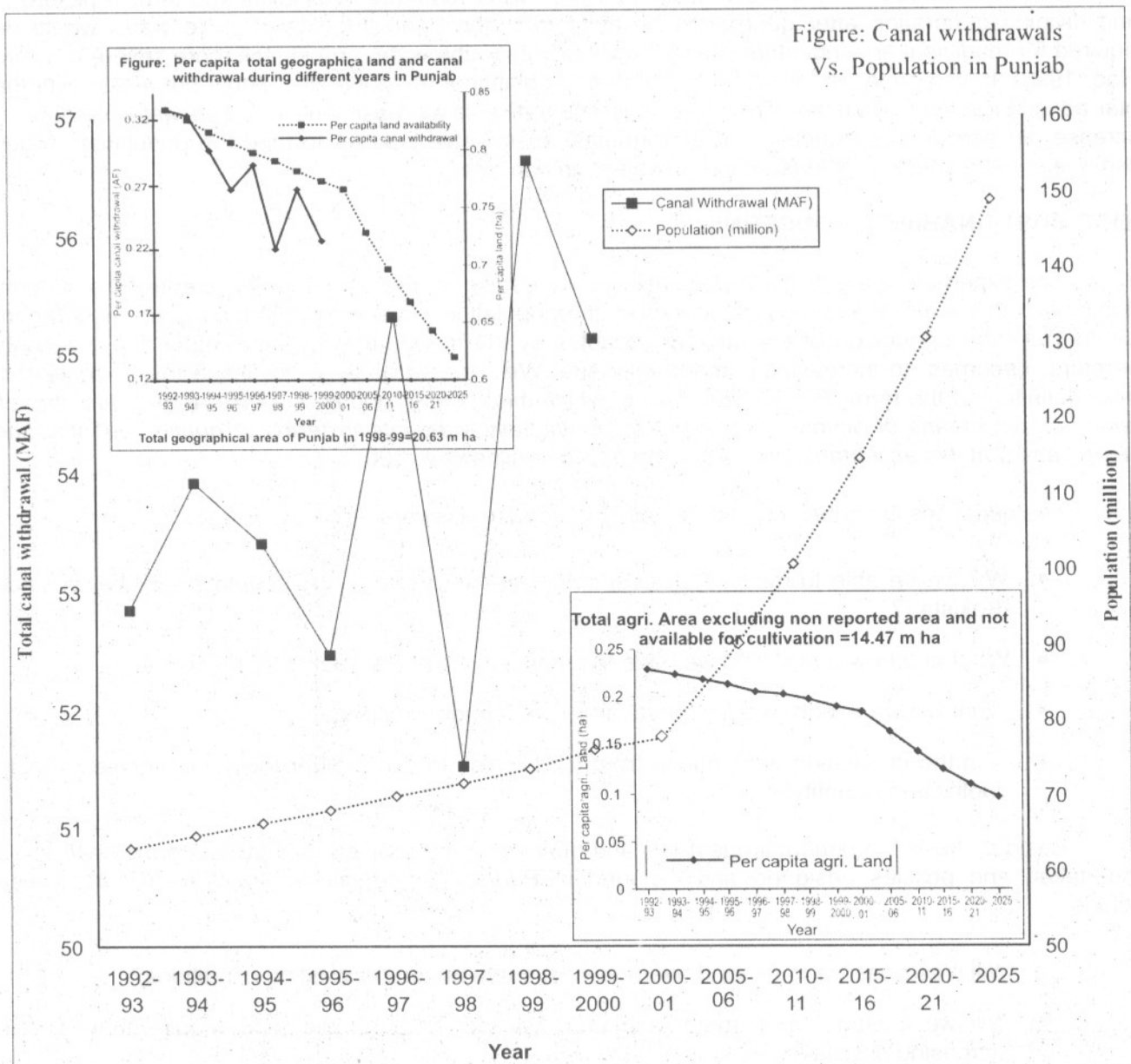


The graph indicates an increase in total water availability at farm gate from 125.12 MAF in 1992-93 to 133.28 MAF in 1999-2000. The line trend for the total withdrawal points out a decrease from 147.41 MAF in 1992-93 and 155.03 MAF in 1993-94 to 134.49 MAF in 1999-2000. This decrease in total withdrawal may be attributed to decreasing canal withdrawals from 102 and 111 MAF in 1995-96 and 1996-97 to 84.58 MAF in 1999-2000. The increase in total farm gate water availability therefore is quite obvious. The line trend of private tubewells indicates the increase in groundwater pumpage from 33.92 and 34.79 MAF in Pakistan in 1992-93 and 1993-94 to 38.27 MAF during 1999-2000.

Total withdrawals from all resources when read together with actual population of Pakistan (111.860 million) in 1992-93 and that of Punjab 62.972 millions points out per capita agricultural water availability of 1.341 AF per annum at country level and 2.341 AF per annum at Punjab level. The agricultural water availability at farm gate for Pakistan further reduces to 1.119 AF for the same year. While calculating Pakistan's population from 1992-1993 to 1997, an annual growth rate of 2.61 % is observed in the census of 1981 when population of the country was put at 84.225 millions. Similarly, 2.64% annual growth rate was used for Punjab to estimate population of 1981 census, when population in Punjab was recorded as 47.292 millions. An annual growth rate of 2.61 and 2.64% were observed to project country's and provincial population from 1998 onward, when a population of

73.621 and 130.580 million was reported for Punjab and Pakistan, respectively. The population projections both at country and at provincial level indicate a widening gap between total water availability for agriculture and increasing demographic pressure on resources.

Estimation of shrinking land and surface water resources when perused in the context of expanding population pressure in Punjab reveals that per capita surface water availability reduces from 0.835 AF in 1992-93 to 0.681 AF in 1999-2000 (sub Fig of Fig 4), when total canal withdrawals in Punjab did not exceed to 52.56 and 52.868 MAF in 1992-93 and 1999-2000 against a population corresponding to 62.972 and 77.560 millions (Main Fig 4).



Another sub fig of Fig 4 points out that per capita land out of total geographical area of Punjab (20.63 m ha as estimated in 1998-99) decreased from 0.328 hectare in 1992-93 to 0.280 hectare in 1998, while on the basis of total agricultural area (net sown + current fallow + culturable waste + forests) of 14.47 m ha (excluding area not reported + not available for cultivation in 1998-99), about an area of 0.230 ha/capita decreased from 1992 – 1993 to 0.197 ha in 1998-99. Corresponding to 0.230 ha/capita land in 1992-93 and 0.197 ha/capita in 1998-99, per capita canal withdrawal share tunes to 0.835 and 0.733 AF. This reflects the water shortage. The estimation for the projected population points out that per capita agricultural land availability would decrease to 0.097 ha for a provincial population of 148.782 million in 2025. This reflects the shrinking of water resource availability and terrible picture of land dividing generation after generation. In addition to the agricultural uses more water would be required for municipal and industrial uses. This would make the water crunch still more severe in future (Haq, 1995). It also provides food for thought that population if not controlled would not match with the total agricultural land available. Therefore, it is imperative to increase and manage water resources, increase per acre food production and to formulate sustainable policies to feed the population, which also needs to be checked at least at the prevalent growth rate.

FOOD SUSTAINABILITY CONCERNS

The experts foresee that our population is increasing so rapidly that it will create food security problems in the years ahead. It is obvious from the population projections that food grain requirement will double if the population of the province doubles by the first quarter of the century. Food security therefore, becomes an increasingly important issue. We have to analyze the issue in the context of basic definition of the term "*FOOD SECURITY*" which means that food is available at all times, that all persons have means of access to it, that it is nutritionally adequate in terms of quality, quantity and variety, and that it is acceptable within the given culture (Khawaja, 2002).

The questions in context of food security that require answers are:

- Will we be able to meet food requirement of the ever growing population of the province /Pakistan?
- What and how much food we have to produce or import to make up the deficit?
- What will we export to buy imports and earn foreign exchange?
- Can the population diet change from food grains to some other food commodities in both quality and quantity?

Besides these fundamental questions and queries, some projects and land reforms have to be undertaken and policies designed and included in Punjab Conservation Strategies (PCS). These include :

- Will it be possible to expand average yield curve under the existing conditions?
- Will we have to bring more land under plough to meet the food requirement of then increasing population?
- Will it be possible to exploit potential yield of the crops?
- Will full potential exploitation of food crops serve the purpose?
- Will we have adequate virgin or barren land (spared from urbanization) to bring under plough to grow more food for population?

- Will there be sufficient agriculture input resources such as water, fertilizers, diesel oil etc?
- How much fertilizer, water and other agricultural inputs we have to quantify?
- Will the existing fertilizer industries, oil refineries and water reservoirs be sufficient to meet food needs of the population, if not, how much to be planned and installed for future?
- Will the prices of produce be compatible with the input prices?
- Can Government exercise control over population?
- Should we start planning right now?

To address the preceding questions and queries food requirement can be predicted. The food energy requirements are estimated from the Recommended Daily Dietary Allowance (RDDA) @ 2550 calories per head per day (Punjab Research Master Plan, 1995). This food energy is converted into food production and the predicted values (Table-2) can be taken as target for production. The food requirements to estimate food production are limited to wheat, rice and sugar only. The requirement from the food ingredients such as pulses, meat, fruits, oilseed, vegetables, milk, fish, eggs etc has not been estimated.

Table 2: Projected food grains and sugar requirement for Punjab and Pakistan (based on energy value)

Parameter	1998	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Mt	Projected estimate (2000-50)											
Punjab												
Wheat grain	8.84	9.31	10.60	12.08	13.76	15.67	17.85	20.34	23.17	26.39	30.07	34.25
Rice grain	2.9	3.10	3.53	4.03	4.59	5.22	5.95	6.78	7.72	8.79	10.02	11.42
Pakistan												
Wheat grain	15.67	16.50	18.77	21.35	24.28	27.62	31.42	35.74	40.65	46.24	52.60	59.83
Rice grain	5.22	5.50	6.26	7.12	8.10	9.21	10.47	11.91	13.55	15.41	17.53	19.94
Sugar												
Punjab	0.88	0.93	1.06	1.21	1.38	1.57	1.78	2.03	2.32	2.64	3.01	3.42
Pakistan	1.57	1.65	1.88	2.13	2.43	2.76	3.14	3.57	4.07	4.62	5.26	5.98

Assumptions:

- 1) Yearly per capita energy requirement was calculated as 930,750 calories.
- 2) Food grains provide 3500 cal/kg and about 60% of the total energy required.
- 3) 160 kg of food grains are required/person/year; wheat provides 75% (120kg) and rice 25% (40kg) of food grains.
- 4) Sugar is estimated @ 12kg/year.

Wheat is the major food grain consumed. Of the total food, cereals provide 60% of the energy, 68% of the protein and 14% of the fat. Of the total cereals, wheat constitutes 72-75% of the amount (kg), 75% of the calories, 82% of the protein and 75% of the fat. Rice constitutes 20-25% of the total cereal amount, 16%, 10% and 6% of the energy, protein and fat, respectively. It is assumed that meat, fruits, fish, milk etc are not within the reach of a common person. The people feed on imbalanced diet with maximum dependence on food grains (PMRP, 1995). That is why major emphasis is laid on wheat and rice crop, the major food grains.

The cereals are the main targets, which need to be achieved in context of population pressure in the coming times. Projected estimates show that in Punjab wheat production as per head requirement on energy basis has to shift from 9.31 million tons in 2000 to about 17.85 million tons in 2025 and to 34.25 million tons in 2050. This target at country level would shift to 31.42 million tons by the end of 2025. It would further increase to 59.83 million tons in 2050. Therefore, what an alarming situation it would be in 2050, if increasing risk to food security was not averted and resources managed. In other words, Punjab would have to take up the target of wheat production set now at the country

level. Similarly, rice will be targeted at 5.95 million tons in 2025, which in Punjab has to further shift to 11.42 million tons in 2050.

How the other people see this food requirement in 2025 at country level is variable depending upon the growth rate observed as below 3% and differences in consumption per capita (Halcrow and ACE, Natl. Water Policy, 2002). The detail is given in Table 3. However, it is an established fact that food requirement in 2050 will be many times higher than that in 2025.

Table 3: Production and projected requirement (Pakistan) for 2025 in million tons (Halcrow and ACE, 2002).

Commodity	2000 Population 140 millions			2025 Population 221 millions	
	Target kg/capita	Requirements	Actual Production	Target kg/capita	Requirements
Wheat	125.3	17.54	20.0	128.0	28.29
Rice	22.3	3.09	5.16	22.7	5.02
Maize	9.3	1.30	1.65	9.8	2.17
Pulses	6.3	0.88	0.90	6.3	1.39
Other grains	4.1	0.57	0.60	3.8	0.84
Fruits	36.0	5.04	6.15	60.0	10.38
Vegetable	30.0	4.20	4.76	42.0	7.27
Sugar	25.0	3.50	3.0	28.0	6.19
Edible oil	114	160	Imports	114	262

FEASIBILITIES TO MITIGATE FOOD INSECURITY

The increase in food production is feasible by three means i.e.

1. Increasing average yield per unit land
2. Bringing more area under plough
3. Controlling urbanization & population

Increasing average yield per unit land

Average yield of wheat in Punjab would have to jump from 2.469 tons / ha in 2001 to 2.77 ton ha⁻¹ in 2025, if the present area (6444 x 10³ ha) under wheat cultivation is to remain unaltered. However, the scenario will be terrible in 2050 when in Punjab an average yield of 5.32 t/ha would be required, if present area under wheat not increased. The average yield will acquire status of near potential yield. At the old average yield of wheat (2.469 t/ha) the total production in Punjab would come to 15.91 million tons against the target fixed at 17.85 million tons in the year 2025. Therefore, yield has to shift to 2.77 t/ha to achieve the target of wheat production in 2025 (Table 2).

The province will have a wheat deficit of about 2.0 million tons in 2025 if average yield and area under production is not increased. In 2050, more area and average yield would require a substantive increase. At country level in 2025, the average wheat yield will have to be raised to 3.81 t/ha if present area of 8261000 ha (2001), not increased. At present (2001) average yield (2.302 t/ha) and acreage, the total yield would be 19.02 million tons. So a deficit of 12.40 million tons would be expected in 2025.

For increasing average yield per hectare we have to concentrate on food production factors i.e.,

- Crop variety (research out high yielding varieties)
- Seed quantity/plant density

- Appropriate seeding /planting time
- Weed/disease control
- Fertilizer
- Irrigation
- Post harvest crop losses

Fertilizer perhaps is even more essential in increasing crop production under interaction with water. The prices of fertilizers by then can be expected soaring very high and may be beyond the control of farmers not linked through cooperative farming. The support price of wheat at the last ten years (1992-93 to 2001-02) at the average growth rate of $80.60 \pm 45\%$ may increase to Rs. 1766 per 40 kg in next 3 decades i.e. 2030 and Rs. 5760 per 40 kg in 2050, when the fertilizer prices will hike unbelievably. In 2050 the price per bag of urea may go to Rs. 2487 and that of DAP and SOP as high as 28421 and 47859/bag if prices increase at the price growth rate of 45 ± 55 and $149 \pm 50\%$ per decade over present prices. A balance will have to be maintained between value and cost of produce and fertilizers and similarly other production elements need VCR adjustments. Benefit to cost (B/C) ratio has to be widened in future, this is not so wide in context of wheat even (Table 4).

Table 4: Cost of production of main crops in selected areas of Punjab

Crops	Itemized cost (Rs/ha): 1 USS=60 Rs											Benefit (Rs/ha)				
	Tillage	Seed	Fertilizer	Pesticide	Labour	Harvesting	Marketing	Land Revenues	Ushar	Irrigation	Total cost (Rs)	Yield t/ha	Price (Rs/ton)	Benefit (Rs)	Net Benefit (Rs)	B/C Ratio
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	n=l x m	o=n-k	p=n/k
Wheat	2500*	1250*	5350**	1000	2500	2600	600	6	2625	59.80/acre	18491	3.5	7500	26250	7759	1.42
Rice	2500*	1250*	4800	2500	3000	2600	600	6	3062	88.53	20406	3.5	8750	30625	10219	1.50
Sugar cane	3000	8000	6000	1300	5000	7500	8750	6	8800	177.16	48533	80.0	1100	88000	39467	1.81
cotton	2750	500	5500	5000	2500	6250	100	6	5000	93.02	27699	2.5	20000	50000	22301	1.80

* Rate of wheat seed certified = Rs 400/Md. Cotton, Rs 20/kg. Sugarcane Rs 40/Md

• Ploughing 1 and cultivation 4 for wheat, rice and cotton (cost of rotavator/acre is Rs.300) while for sugarcane cultivations are 4 and ploughings 2.

** Fertilizer rate for Urea Rs 400/bag, DAP Rs 750/bag, Potash Rs, 550/bag on the basis of recommended dose

Yields may stagnate to crop potential; we cannot go in producing beyond that crop potential. The fertilizer prices associated with manufacturing input may increase even at the stagnating yield point. To keep balance in farmers' daily expenditures and for repayment of the input costs, there would be no option other than increasing wheat prices to the maximum. Besides increasing near potential average crop yields through improved crop production and irrigation techniques such as high efficient irrigation strategies, the possibility of bringing more virgin land under plough or up-lifting the productive potential of soil cannot be ruled out.

Bringing more area under plough

A total area of 7.23 millions hectares in Punjab would be required by the end of year 2025 if the average yield of wheat is to stagnate @ 2.469 t/ha (Table 5). This would require addition of about 1.0 million hectares to the present area of 6.244 million hectares in 2025 i.e. 16% increase would be required over the existing wheat cropped area of 6244 thousand hectares (2000-01). The statistics reveal a total culturable area of 1.72 million hectares in Punjab. Thus, about 1 million ha culturable waste brought under plough may provide the required wheat grains targeted at 17.85 million tons in the year 2025. Anyhow, the inclusion of current fallow (1060 thousand hectares) area in agriculture can curtail the wheat imports to the province and the country as a whole. However, we have to plan projects to bring an area of about 41.67 thousand hectares per year under plough from 2002 to 2025 (2002 inclusive) in 24 years.

Table 5: Projected land and water requirements in Punjab during 2025 and 2050 for only one *Rabi* and two *Kharif* crops

Commodity	2025 with present yield 2000-01				With 50% increase in yield in present yield			
	Average yield in Pb. 2000-01	Required production (mt)	Area (m ha) required	Water requirement at farm gate (MAF)	Of farm 60% +loss	Area required (m ha)	Farm gate water requirement (MAF)	Of farm 60% +loss
1. Wheat	2.469 t/ha	17.85	7.23	17.87	44.68	4.802	11.91	29.78
2. Rice	1.58	5.95	3.77	48.91	122.28	2.51	32.56	81.40
3. S.Cane (stripped)	43.5	17.8	0.41	5.91	14.78	0.270	3.89	9.73
				<i>Rabi</i> 17.87 <i>Kharif</i> 54.82	44.68 137.06	<i>Rabi</i> <i>Kharif</i>	11.91 36.45	29.78 91.13
Commodity	2050 with present yield 2000-01				With 50% increase in yield in present yield			
	Required production (mt)	Area (m ha) required	MAF farm Gate	Of farm 60% +loss	Area required (m ha)	Water requirement at farm gate (MAF)	Of farm 60% +loss	
1. Wheat	34.25	13.87	34.27	85.68	9.26	22.88	57.2	
2. Rice	11.42	7.23	93.80	234.50	4.82	62.53	156.33	
3.S.Cane (stripped)	34.20	0.79	11.30	28.45	0.52	10.047.50	18.75	
			<i>Rabi</i> 34.27 <i>Kharif</i> 105.18	85.68 262.95		<i>Rabi</i> 22.88 <i>Kharif</i> 70.03	57.2 175.08	

Note: This table can be read together with table regarding projected population and food requirements. Water requirement for wheat is assumed to be 12 inches per crop, Rice = 63 inches (OFWM), sugarcane = 70 inches (Spring, OFWM). Sugarcane requirement given in the above referred table is converted into the weight of stripped S. Cane @ 100kg Cane Sugar = 1000kg sugar cane (1:10). Generally ratio of cane sugar to S. cane varies from 7 to 11 % by weight. (Ref. ONFWM Vol.6 Irrigated Agri. 1997. MINIFA, Islamabad: 345p)

The fertilizer requirement associated with the new area to be brought under wheat cultivation (41.67×10^3 ha \times 24) would demand after 24 years the fertilizer nutrients of 0.156 million tons @ 155.78 kg/ha total nutrient use in Punjab. The total nutrient use including 6244 thousand ha already under wheat in 2001 will be 1.13 million ton in 2025. This highlights the total pressure on fertilizer industry of 1130 thousand tons (total nutrient) during *Rabi* season in 2025 for wheat crop only against the present total fertilizer nutrient off-take of 1173.27 thousand tons in Punjab during *Rabi* 2002 for all types of *Rabi* crops. The total fertilizer nutrients at the same use rate and wheat average of 2000-01 would increase to 2.16 million tons by the year 2050 for an area of 13.87 m ha under wheat. Need therefore, would be either to install more fertilizer industries or import fertilizers in future to make up the deficit of 986.73 thousand tons of nutrients. The agricultural implements will also have to be adjusted in addition to thinking of diesel prices and tubewell manufacturing. This also highlights the need of water reservoirs to supply water for wheat (@1AF/season) of 17.87 MAF at farm gate (for 7.23 m ha area) to produce 17.85 mt of wheat in Punjab (Table 5) in 2025 in *Rabi* season, if the average yield of wheat is to be retained at 2.469 t/ha against the total prevalent quantity of 18.87 MAF allocated to Punjab. With 60% water losses (Ramzan, 2002) the volume required to meet farm gate requirement of 17.87 MAF for wheat, water figure would come to 44.68 MAF in *Rabi*.

Controlling urbanization and population

It can be predicted that further reduction in population growth rate appears unlikely for some reasons, explained below :

- Movement of labour from rural to city areas for employment reduces the labour availability in the rural areas, consequently, the size of a farmer's family needs to be maintained to perform agricultural operations at the farm
- Women have less influence to control family size because of their submissive role in our society

- Aged people are looked after by their own children, hence large family size is considered to be essential for their own survival in old age
- Education- general plight and socio-economic situation in the rural areas is unable to promote education – the major contributing factor to initiate a reduced birth rate

Integrated Approach

Besides motivating the people to exercise control over population the endeavours be made in an integrated fashion that is more land should be brought under plough and more crop yields should be obtained at the same time. It can be estimated that if average yield of wheat in Punjab were increased to 3.5 t ha^{-1} , which is a realistic increase ; it would contribute about 21.854 million tons of wheat from 6244000 ha. Similarly, bringing 860 thousand hectares (1/2th of culturable wasteland) land under plough at the realistic increase in average yield of wheat, about 3.01 million tons of wheat grain can be produced. Thus, total figure for wheat production comes to 24.864 million tons against the target fixed at 17.85 million tons for a population of 148.782 millions in the year 2025 (Punjab). It would help reserve food for emergency period equivalent to 7.0 million tons per year.

It is also emphasized that step-by-step reclamation of salt-affected lands is important in context of ever expanding population, ever increasing food needs and rapid urbanization of agricultural lands. The legal restrictions we have to impose to prevent encroachment of productive agricultural land. It is also rationale to think that we must produce surplus food for export to earn more foreign exchange. We have to produce other crops such as cotton and fruits for export to earn foreign exchange to purchase other requirements and necessities of the province and the country as a whole. It is right time to think of widening gap between food production and consumption in context of population pressure in the coming times. If proper strategies not adopted or policies not framed, the food security would be at the highest risk. It will be wise to review the today's situation and plan right now for tomorrow. It is the high time to use tomorrow's technology today.

Scenario 2050

The data (Table 2) reveal that little but very sharp and wise efforts are required to over-ride food security risk expected in 2025. However, the scenario at both Punjab and Pakistan level is horrible. Wheat grain demand has to shift to 34.25 and 59.83 million tons in Punjab and Pakistan, respectively if population growth rate estimates of 2.64 and 2.61% for Punjab and Pakistan. Similarly, demand for sugar and rice grains would also increase linearly. If we look at wheat production only in light of present wheat production area of 6244000 ha (2000-01) in Punjab, the near potential yield has to be the average yield (5.49 t/ha) in future. It is not realistic to everybody to exploit the potential of the existing varieties, which varies from 50-70 t/ha. On the other hand, if inputs including water are managed and all the culturable waste and current fallow (1.06 and 1.72 m ha, respectively) area is brought under plough, it at present average (2.469 t/ha , 2000-01) will give a wheat production of 6.864 million tons. The total yield figure including area already under wheat cultivation (6244000 ha) would become to 22.283 million tons against the provincial target of 34.25 million tons. What a terrible situation?. It reflects that we have to raise the average wheat yield bringing more area under plough and avoiding uncontrolled urbanization at the productive agricultural lands. In 2050, there would be no current fallow or culturable waste left to feed projected population of the province. All the area in addition to the present (2001) would have to be brought under plough with average yield of wheat fixed at 3.80 t/ha . The policy makers would have to control population growth rate (below 2.6%) and asking plant breeders to evolve / breed wheat varieties of genetically high potential at the same time.

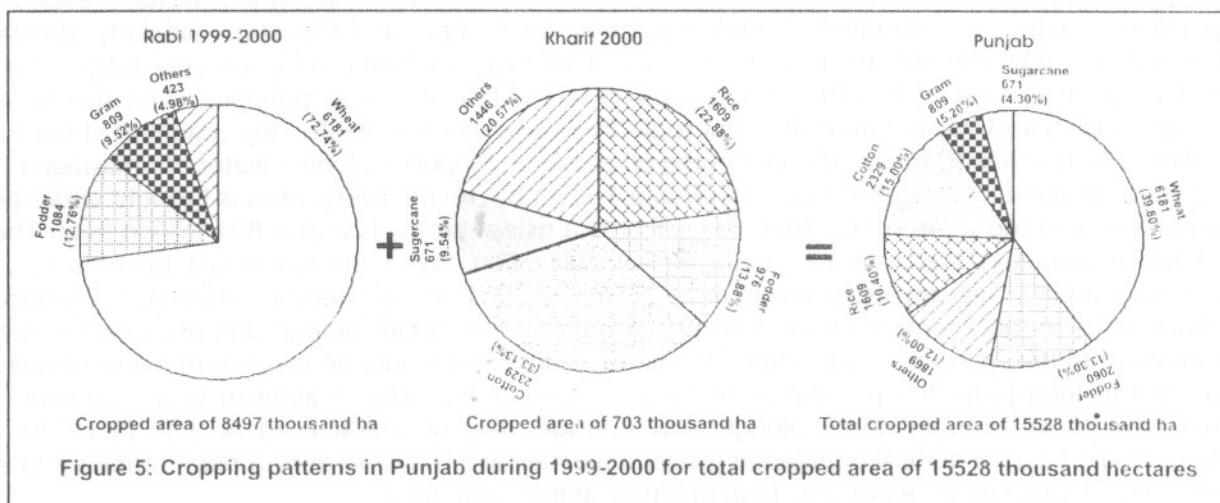
Thus we have to adjust a total area of 9024 thousand hectares under wheat production in Punjab (including all culturable waste, current fallow and the one taken up in 2000-01) to feed

population in 2050. It would require at farmgate water availability of about 23 MAF only for wheat-not to speak of other competitive *Rabi* crops. The Figure 23 MAF at 60% losses may assume value of 57.5 MAF. It necessitates the construction of water storage facilities to meet future demands of the population.

The Pakistan Scenario

The population scenario further gives a horrible picture and by the end of 2050, an annual wheat production of 59.83 million tons would be required if population increases at the rate of 2.61% against the wheat production of 19.018 million tons in 2000-01 on a total wheat production area of 8261 thousand hectares. The average yield would become 7.24 t/ha if present (2000-01) area and average yield are not increased in 2050. This is not rational to increase average yield to such a high level. On the other hand, a yield gap of 40.81 million tons (59.83-19.018) has to be met. Raising average yield to 3.80 t/ha of the existing area of the country (under wheat) about 31.39 million tons can be produced still leaving a gap of 9.42 million tons, which must be filled with culturable waste and current fallow area including unreclaimed salt-affected lands of the province. Out of the total geographical area of Pakistan viz 80 m ha, its cultivable area is 35.4 m ha, cultivable waste land is 8.6 m ha, cultivated area measures 23.3 m ha, water logged and salinity affected areas in the Indus Basin is 6.8 m ha and salinity affected area out of the Indus Basin is 5.6 m ha (Ramzan, 2002). These statistics reveal the need to cultivate almost half of the 8.6 m ha of cultivable wasteland to have at least an average yield of 2.19 t/ha. It points out that within next 48 years the cultivable waste should be brought under plough @ 89.58 thousand hectares per year. The cultivable wastelands of Punjab will exclude from cultivable waste of the country. The remaining area at country level must be recovered from the salt-affected area. Therefore, time has come when we cannot live without harnessing our soil and water resources. The barren lands including salt-affected land cannot be over looked in the context of year 2050. Short-term policies and decisions in this context surely would not provide a sustainable solution to our problems.

The above discussion reveals that at country level we have to put a total area of 12561 thousand hectare under wheat (including cultivable waste + present 8261thousand ha) which @ 1AF water for requirement of wheat would need 31 (04 MAF farm gate water. Adjusting this figure to 60% water losses about 77.60 MAF water would be required in *Rabi* to meet only wheat requirement of water in 2050. What about other *Rabi* crops, while present inflow does not exceed 18.87 MAF in *Rabi* season and 37.07 MAF in *Kharif* season for the cropping patterns being observed in Punjab (Fig 5).



This situation necessitates enhancement of the water storage capability of the existing dams/ reservoirs, construction of the new ones in addition to devising new ways and means of high efficiency

irrigation methods and techniques. The groundwater exploitation on judicious lines may also help as a supplement to canal water supplies (Javaid *et al.*, 2000). Water is a finite resource; there is a dire need for its conservation, careful and efficient use. Our religion Islam is much more emphatic on this subject enjoins that everyone is accountable for every bit of food and every drop of water that he uses or misuses.

THINKING OF WATER DEVELOPMENT POTENTIAL TO MEET WITH RISK

The surface water in Indus Basin maximizes to 144 MAF of which 105 MAF is diverted to the canal irrigation system. We must cut down our line losses (about 60% as reported by Ramzan, 2002) of irrigation water.

The other sources of water also need to be explored. It has been reported that there are 14 hill torrents areas in the country, having a potential of 18.6 MAF at 1204 conservation sites. This water is sufficient to irrigate 6.5 m ha cultivable waste land in Balochistan, NWFP with 4.5, FATA with 2.8, the Punjab with 2.7 and Sindh with 0.78 MAF. This torrential water should not be allowed to go waste. The experts also report that an annual average of 39 MAF water (ranging from 8 MAF to 92 MAF for 70 – 100 days) escaping below *Kotri* fall into the sea is unutilized during the summer. This large quantity of water can wisely be stored to serve an additional reservoir (Ramzan, 2002). Similarly, we must think of 97% of the total water i.e. sea. There seems bright scope of seawater agriculture in deserts. According to another information (Halcrow & ACE) Punjab has 1.41 million acres culturable waste land with additional 2.71 MAF water conservation potential (Table 6).

Table 6: Land and water conservation potential of Hill Torrents (Halcrow and ACE, 2002)

Province	Culturable waste land (million acres)	Additional water conservation potential (MAF)
Federal	0.67	2.84
NWFP	2.57	4.56
Punjab	1.41	2.71
Sindh	1.36	0.72
Balochistan	11.56	4.86
Pakistan	17.13	15.69

Note: The potential can be further increased by another 20% by using latest techniques of rainfall harvesting.

Need therefore, be realized to leave no stone unturned in context of water exploitation and future needs. The above scenario indicates that the major part of the cropped area is put under wheat every year followed by cotton, fodder, Rice and others. The cropping pattern in Punjab (1999-2000) indicated in pie graph (Fig 5) points out that how much water would be required even to irrigate the present-cropped area, which is already 4-6 times under supplied.

It therefore, be realized that water shortages be compensated through tactic and strategic policies and decisions so as to feed future population pressure.

It evident from table 5 that at presents status of surface water resources we will be unable to meet the projected water requirement of wheat in *Rabi* and that of Rice and S. cane in *Kharif*. By increasing average crop yields by 50%, the water requirement can be curtailed to some extent. The water quantum further increases when 60% line losses of irrigation are considered. This needs wise planning and immediate implementation of the water reservoir projects with sincerity. Really, we must realize as to what we are up to and what we have so far achieved during the last 55 years. No doubt, we can create wonder and miracles if not divided on our national priorities, orders, and projects of great national interest.

CONCLUSIONS

1. The demographic pressure on Punjab will increase from the 1998 figure 73.62 to 148.78 millions in 2025, while it would increase to 285.41 millions in 2050 (based on an annual growth rate of 2.64%).
2. Projected estimates show that in Punjab wheat production on energy basis has to shift from 9.31 millions tons in 2000 to about 17.85 millions tons in 2025 and to 34.25 mt in 2050. This target at country level would shift to 31.42 mt by the end of 2025 and to 59.83 mt in 2050, if population goes on increasing at the prevalent growth rate.
3. A total area of 7.23 million hectares in Punjab would be required by the end of 2025 if the average yield of wheat is to stagnate at 2.469 ton/ha. This would require addition of 986 thousand hectares to the present area of 6244 thousand hectares.
4. The current fallow area (1060 thousand hectares) should be used to curtail the wheat imports to the province. The projected estimate reveals that we have to plan projects to bring an area of about 41.67 thousand hectares per year under plough from 2002 to 2025 in next 24 years.
5. The rice and sugar requirement would increase from 2.9 and 0.88 mt in 1998 to 5.95 and 3.14 million tons in 2025, while the corresponding requirement for rice and sugar may increase to 11.42 and 5.98 mt in 2050.
6. In context of expanding population, per capita surface water availability reduces from 0.835 AF in 1992-93 to 0.681 AF in 1999-2000, when total canal withdrawal in Punjab did not exceed 52.56 and 52.868 MAF in 1992-93 and 1999-2000 against a population corresponding to 62.972 and 77.560 millions. Based on total agricultural area (14.47 m ha) about an area of 0.230 ha per capita in 1992-93 decreased to 0.197 ha in 1998-99.
7. The projected farmgate water requirement for wheat, rice and sugarcane in 2025 at their present average yields account to 17.87 MAF in *Rabi* and 54.82 MAF in *Kharif*. However, by increasing 50% average yield these requirements can be reduced to 11.91 and 36.45 MAF during *Rabi* & *Kharif*.
8. At the prevalent average yields of wheat, rice and sugarcane the farmgate water requirement in 2050 would be 34.27 and 105.18 MAF during *Rabi* and *Kharif* seasons, while 50% increase in their average yield may curtail this level to 22.88 and 70.03 MAF flow in *Rabi* and *Kharif* seasons.
9. In context of food security, the Scenario 2050 is more horrible than the often spoken scenario 2025.

RECOMMENDATIONS

1. Population growth rate further should be reduced or maintained at 2.6% through awareness campaign among masses.

2. While projecting food requirements, the daily dietary allowance (2550 calories per head per day) and yearly per capita energy requirement (930,750) must be taken into consideration, which is on average basis.
3. An integrated approach should be adopted to combat with the food insecurity risk.
4. The tactic efforts provide a time being solution. Short term polices and decisions to harness the soil and water resources including reclamation of barren lands can not provide a sustainable solution to our problems.
5. A balance must be maintained between the population growth rate and that of the agricultural growth rate.
6. The 50% of the average potential of food crops must be exploited to cater for human food requirements and curtail the supply of water and addition of more land, in addition to striving for high yielding crop varieties.
7. Urbanization of land must be viewed seriously in addition to directing the efforts towards bringing more area under plough and making the efficient use of the available land and water resources.

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