Sustaining Irrigated Agriculture for Food Security: A Perspective from Pakistan

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Paper presented at the

Pakistan Engineering Congress

On the occasion of

World Water Day

March 24, 2012

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Abstract

Humanity is facing an enormous challenge in managing water to secure adequate food production. By the middle of this century, the world's population is projected to reach 9.1 billion, 34 percent higher than today. Nearly all of this increase will occur in developing countries. In order to respond to the expected demand of this larger, more urban and, on average, richer population, food production must increase by about 70% as estimated by the FAO. It is an enormous task because the required increase in food production to meet future needs will have to be achieved with fewer land and water resources. Food insecurity in Pakistan is a product of poverty and inadequate food availability. During the past two decades, 1987-2007, food poverty incidence in the country shows that about one-third of the households were living below the food poverty line and they were not meeting their nutritional requirements. The incidence of food poverty is higher in rural areas (35%), than in urban areas (26%). In Pakistan, irrigated agriculture is vital for future food security because it produces more than 90% of the total grain production. With the decreasing amounts of available water, the challenge of sustaining irrigated agriculture is increasing by the day. This paper reviews the situation in Pakistan and suggests pathways to sustain irrigated agriculture in order to meet future food requirements.

Keywords: Irrigated agriculture, food security, Pakistan, water resources, water productivity

Introduction

Feeding the world's growing population and finding the land and water to grow the food continues to be a basic and sizeable challenge. By the middle of this century, the world's population is projected to reach 9.1 billion, 34 percent higher than today (GWP, 2011). Nearly all of this increase will occur in developing countries. In order to respond to the expected demand of this larger, more urban and, on average, richer population, food production must increase by about 70% as estimated by the FAO.

The Indus River basin forms the back bone of Pakistan's economy. It supplies water to the largest contiguous irrigation system in the world that provides 90% of the food production and contributes 25% to the GDP. But it is also one of those countries that could face severe food shortages which are intimately linked to water scarcity. It is projected that population of Pakistan will increase to 250 millions in 2025 reducing the water availability per capita to less than 600 cubic meters (Bhutta, 1999). The shortfall of water requirements would be about 32 percent which will result in 70 million tons of food shortages by the year 2025 (ADB, 2002). Therefore, the need for further development of new resources, adoption of water-conservation measures and improving the productivity and performance of existing irrigation system is being stressed at all forums.

Recent estimates suggest that the surface irrigation system of the Indus Basin will reduce its surface storage capacity by 30 percent by 2025 due to climate change and siltation of main reservoirs. This reduction in surface supplies and consequent decreases in groundwater abstraction will have serious effect on irrigated agriculture, which produces most of the agricultural production in Pakistan. This situation has threatened the food security of 180 million people living in Pakistan.

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Climate change also is posed to adversely affect agricultural production. It is predicted that after an initial period of high flows in the form of storms due to faster glacial melt there will be a terrifying decrease in inflows of anywhere between 30-40 percent into the Indus river system (World Bank, 2006). Similarly IFPRI projects that decreased flows will reduce grain yields by 15-20 percent in Asia. While the actual affects are likely to be heterogeneous and region specific, yet in most cases it will hurt poorest the most because they will have the least capacity for adaptation.

The food insecurity-poverty nexus is also pervasive in Pakistan. The government's task force on food security has underscored the importance of achieving an average agricultural growth of at least 4% per annum in the next decade to ensure food security and poverty reduction. Supply side solutions aimed at providing more water will not be available as in the past. Current low productivity in comparison to what has been achieved in other countries under nearly similar conditions points to the enormous potential that exists. Since agriculture in Pakistan is essentially irrigated agriculture, it is imperative to assess the current performance of the Indus basin irrigation systems, diagnose causes and constraints for low productivity and suggest strategies to ensure sustainability of the basin and livelihood of millions who are dependent on this basin. This paper suggests the importance of improving sustainability of irrigated agriculture to ensure food security for Pakistan.

Increasing gap in supply and demand

Population growth in Pakistan has been, and continues to be, high. The total population in 1950 was 40 million, which grew up to 80 million in 1980 and has reached to an estimated 185 million in 2010 (UN, 2009). More than 4 million people are added every year and according to UN estimates the population in Pakistan will reach to 250 million in 2025 and 335 million in 2050. The percentage of urban population will increase from the current 35% to 52% by 2025. As a result, water demand for domestic, industrial and non-agricultural uses will increase to 10% of the total available water resources by the year 2025 (Bhutta, 1999).

The per capita water availability in Pakistan has already fallen from 5,000 m^3 in 1951 to just 1000 m^3 in 2005 and is expected to reduce to about 700 m^3 by 2025 and 525 m^3 by 2050 (Figure 1). This is roughly the value below which water availability becomes a primary constraint to life (Engelman and Leroy, 1993). Although the surface flows of the Indus River and its tributaries available to Pakistan are quite significant, these are characterized by a great variation. Against the average annual inflow of 175 BCM, the historic data from 1922-97 indicates a high of 230 BCM (34% higher than average in 1960) and a low of 120 BCM (30% lower than average in 1975). About 65% of the total river flows comes from the Indus alone, while the share of Jhelum and Chenab is 17 and 19 percent, respectively. The Kabul River contributes a maximum of 42 BCM and a minimum of 15 BCM with an annual average of about 25 BCM to Indus.

The water requirements for irrigation in the Indus Basin are estimated at 250 BCM in 2025 against the projected availability of 185 BCM. Even by exploiting the full groundwater resources, the water availability will not be more than 190 BCM. Considering the reduction in present storage capacities and non-availability of additional storage facilities, the shortfall of water requirements would be about 50 percent by the year 2025 (Alam and Bhutta, 1996). This large shortfall in water availability will lead to serious food shortages and rising food prices. As opportunities for development of new water resources diminish and costs rise, increasing the productivity of existing water resources becomes a more important and attractive alternative. Therefore there is every motivation to designate more capital and efforts to increase the productivity of land and water and the sustainability of water resources management[1].

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[1] Productivity of water (kg m^{-3}) is expressed in terms of yield (kg ha^{-1}) produced per unit evapotranspiration (m). Sustainability refers to management of water systems which does not lead to environmental degradation (waterlogging, salinization and desertification).

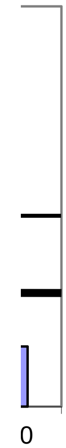

Figure 1. Declining availability of water in Pakistan (m^3/capita/year).

Irrigated Agriculture in Pakistan

The greatest water problem, which made most of the Asian countries still far away from achieving food security, is our failure and inability to link environmental security, water security and food security (Figure 2). Irrigated agriculture is the center stage of this because more than 80-90 percent of the fresh water resources are used for agriculture. On the other hand, agriculture is also the biggest source of water wastage due to its low usage efficiency. Therefore, improving irrigation water management to reduce the losses even by 10%, will lead to an enormous increase in the available water resources.

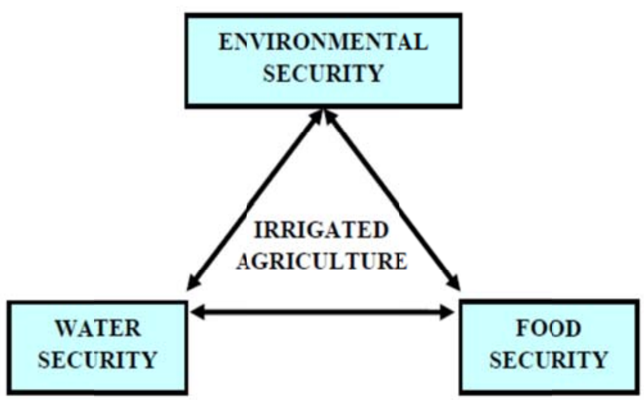

Figure 2. Food security, water security and environmental security relationship (Source: Hamdi, 2004)

Due to arid and semi-arid conditions prevailing in most parts of Pakistan, annual evapotranspiration (ET) in the Indus basin varies between 800 mm in the north to 2000 mm in the south. The rainfall amounts follow the similar trends with only 100-150 mm per year in the south to 700-800 mm per year in the north. The direct contribution of rainfall to total crop water requirements is only 15% and the rest has to come from irrigation supplies (Qureshi et al., 2007). Therefore irrigated farming is the most economical and remunerative form of agriculture. Irrigated lands provide more than 90% of the agricultural production and are major user of the water resources. As the surface water supplies are neither sufficient nor reliable to meet the crop water requirements, groundwater resources are widely exploited to fill the gap between supply and demand (Shah et al., 2003). Currently 1.2 million private tubewells are exploiting about 50 BCM of water annually, which accounts for 50% of the total water available for agriculture (Qureshi et al., 2008). The estimated number of users is over 2.5 million farmers who exploit groundwater directly or hire the services of tubewells from their neighbors.

With a served area of 16.7 million hectares and available irrigation water of 136.7 billion cubic meter (BCM), the applied gross water depth comes to 820 mm. Rainfall retained in the root zone effectively adds an estimated 200-300 mm to the crop water availability in the north and only 50 mm in the south. In view of the high evapotranspiration (ET) and severe salinity environment under which the irrigated agriculture in the Indus basin is practiced, the available water is only marginally sufficient for basin wide year round high intensity cropping (Bhutta and Smedema, 2007). Despite the enormous water shortage, water for agriculture in Pakistan is still not used efficiently. Conveyance losses in unlined canals and watercourses are 25% and 30%, respectively. The application losses in the field are around 25-40%. The overall irrigation efficiency of irrigated areas is estimated to be hardly 36% (Kahlown et al., 2001).

The major concerns regarding performance of irrigated agriculture in Pakistan are low crop yields, water losses in the irrigation system and low water use efficiencies .The average yields in Pakistan are low for wheat and rice, being 2276 kg ha^{-1} and 1756 kg ha^{-1}, respectively. There is a great variability in crop yields with some farmers achieving yields of 3874 kg ha^{-1} for wheat and 3545 kg ha^{-1} for rice (Qureshi, 2004). In addition to water shortage, lack of inputs and poor irrigation practices, soil salinization is the major factor for low crop yields. Salt-affected soils have become an important ecological problem in the Indus Basin—an estimated 6 million ha are already afflicted, about half of which are located in irrigated areas (Qureshi et al., 2004).

Irrigated Agriculture and Food Security

Irrigated agriculture is a vehicle for the provision of basic needs and the reduction of vulnerability to food security. Analysis of information in Asia shows that irrigation has helped in increasing the most crop yields by 100-400 % (FAO, 1996a). This has continued to decrease food prices. These reductions have had a positive impact on the real increases of the urban and rural poor, who spend a large proportion of their income on basic foodstuff.

On the other hand Pakistan has built a huge irrigation system but in spite of this Pakistan’s agriculture continues to suffer from low productivity relative to world levels (GOP, 2000). Agricultural growth rates have dwindled down to 2-3 percent per annum from 1994-95 to 1999-2000, which fell further to minus 2.5 percent during 2000-2001 (GOP, 2000). Average yields of all crops especially irrigated wheat, rice, cotton, sugarcane and oilseeds are one of the lowest in the world and significantly low as compared to countries like USA, China, France, Mexico, Egypt, Thailand and India (Table 1) (Qureshi, 2008).

Table 1. Average yields of major crops in Pakistan and range of other countries (Kgs/ha).

Country	Wheat	Cotton	Rice	Maize	Sugarcane
World	2720	1788	3916	4343	65802
India	2670	754	3210	2160	68049
China	4780	3978	6340	5410	66802
Egypt	6006	2654	-	-	119838
Maxico	5151	-	-	2437	74746
France	7449	-	-	9914	-
Pakistan	2770	1867	3190	3240	60852

Low efficiency of irrigation system and poor irrigation management at farm and system levels has led to reduction in crop yields (an overall reduction of 25% and a high of 40-60% in Sindh), lower overall agricultural productivity and loss of cultivable land. Figure 3 shows that over the last decade there has not been any improvement in the yields of major crops in Punjab.

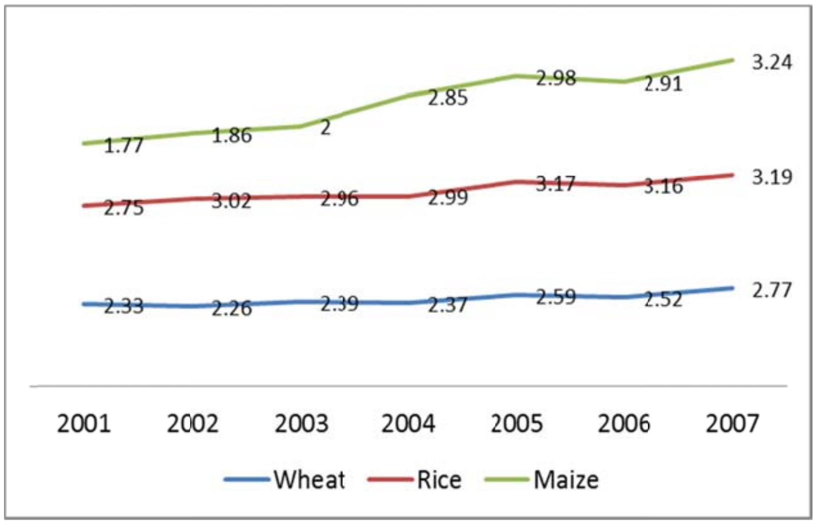

Figure 3: Stagnant crop yields of three major crops in Punjab.

As discussed before, system losses are very high therefore increasing irrigation efficiency will result in improved crop yield and overall agricultural productivity. In the "*business as usual*" scenario, shortfall of water will result in serious food shortages in the years to come and will severely hurt the national economy and livelihood of millions. Estimated requirements of the agricultural commodities for the project population in 2025 are given in Table 2.

Table 2. Projected food requirements and productions for the year 2025 (Million Tons).

Crops	Requirement	Production	Shortfall
Food-Grains	50	31.5	18.5
Sugarcane	82	46.4	35.4
Cotton (lint)	3.5	2.7	0.8
Pulses	1.9	1.4	0.5
Oilseed	3.3	1.5	1.8
Vegetables	14.3	9.0	5.3
Fruits	16.1	9.0	7.1
Total	171	102.8	69.4

Source: ADB water Sector strategy for Pakistan, 2002.

It is estimated that to meet the food requirements of the country, cultivated area of wheat would need to increase by 46% at present yield levels. Similarly areas for other crops will need to be increased. However, given the present situation of water resources, it will not be possible. Therefore the only way to achieve this food target is to increase water productivity. The productivity of water in Pakistan is about the lowest in the world. Figure 27 shows that for wheat, for example, it is 0.5 kg/m^3 as compared to 1.0 Kg/m^3 in India and 1.5 Kg/m^3 in California (IWMI, 2000). The maize yields in Pakistan are very low and there is a tremendous scope for substantial improvements in the maize yields. In terms of water productivity, maize has a factor of nine between lowest in Pakistan (0.3 Kg/m^3) and highest in Argentina (2.7 Kg/m^3). This reveals that there is a substantial scope for increasing water productivity which needs to be harnessed. Poor management of irrigation water at the farm level is usually held responsible for low water productivity values in Pakistan. However, one should realize that water is just one input to the overall agricultural production system. Unless we are not able to improve our crop yields, productivity of water will remain low. Recent analysis of irrigation practices in India and Pakistan has shown that Pakistan is comparable with India so far as water use efficiency is concerned. The major reason for higher crop yields and water productivities in India is their higher nitrogen use. Table 3 and 4 shows comparison of yields and water use efficiency between India and Pakistan. It is clear that we are 12% less efficient in using water for wheat crop but we are 18% more efficient in using irrigation water for rice crop. However, nitrogen use in India for wheat and rice crops is almost double than in Pakistan. This is perhaps the major factor in increasing their yields. Therefore Pakistan need to focus on all inputs (not only water) if we are serious in increasing our irrigated crop yields.

Table 3: Comparison of yields of major crops between Pakistan and India.

Crops	Total Production (million tons)	Yield-Pak-Punjab (Tons/ha)	Yield-Indian-Punjab (Tons/ha)
Wheat	**24**	**3.2**	**4.2**
Rice	**7**	**3.6**	**4.6**
Maize	**3.6**	**3.2**	**4.3**
Sugarcane	**50**	**6.1**	**6.8**
Vegetables	**12**	**-**	**-**
Fruits	**7**	**-**	**-**

Table 4: Comparison of nitrogen use and water use efficiency for wheat and rice between Pakistan and India.

Crop-Fertilizer use	Indian-Punjab	Pakistan-Punjab
Wheat		
Total nutrients ($N+P_2O_5+K_2O$) (kg/ha)	246	174
Estimated irrigation water use (m^3/ha)	2200	2500 (12%)↓
Grain yield (tons/ha)	4.2	3.2
Rice		
Total nutrients ($N+P_2O_5+K_2O$) (kg/ha)	209	139
Estimated irrigation water use (m^3/ha)	1890	1600 (18%)↑

For sustainable rural development and to enhance food security, food production should be increased in a sustainable way. This will involve education initiatives, utilization of economic incentives and the development of appropriate and new technologies, thus ensuring stable supplies of nutritionally adequate food, employment and income generation and natural resources management and environmental protection.

The development of irrigated agriculture brings a range of potential benefits at regional and national level. It contributes to economic growth by generating export crops, reducing imports and thus saving foreign exchange and increase food supplies, which may lead to lower prices. Irrigated agriculture contributes to increase income from production and employment, so that families can gain access to schooling, health and welfare services.

Figure 4 describes the key elements for assessing food security. Food security is basically governed by the balance between food demand and supply, both of which are primarily governed by the biophysical and socio-economic resources and constraints of the region. Food demand is a function of population size, its income and the diet used by the average person. On the other hand, regional food production depends on the agro-technical feasibility of various land use types considering the regional resources and constraints. In combination with environmental impact assessment and socio-economic possibilities, gross food production is assessed. Together with food stock and possible food aid, net food supply can be determined (Aggarwal et. al., 2001).

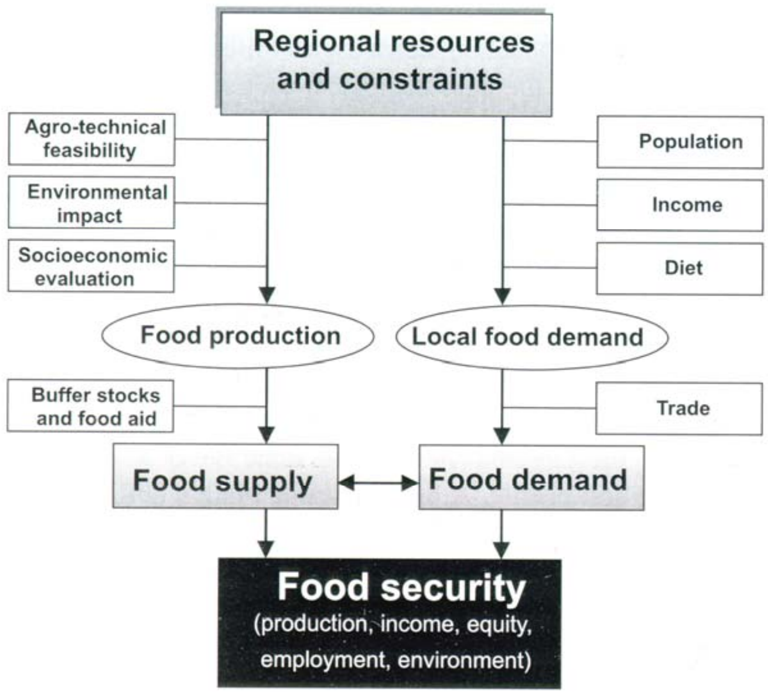

Figure 4: Operational steps for sustainable food security in Pakistan

Ensuring Food Security

An abundance of food at low prices in the world markets does not ensure food security at the country or household level, nor does it help countries to purchase imports to supplement national food supplies (World Bank, 1996a). The poor tend to spend a high proportion of their income, perhaps 50-80 %, on food consumption and water. Hunger and poverty are therefore closely linked. In order to alleviate poverty, poor people need adequate means to obtain food in the quantities and qualities needed for healthy life and generate access to skills, technology, markets and productive resources such as land and capital.

Over the past 25 years, there has been progress in improving the living standards of the people in developing countries. However, even today when the world is producing enough food to provide every person with more than 2700 calories per day, there are still over 800 million people in the developing world who suffer from chronic under nutrition. Severe in-equality in land and income distribution prevents the poor from reaping the full benefits of food availability (IPTRID, 1999).

Although the overall per capita dietary energy supply in South Asia has increase from 2330 calories per day to 2400 calories per day, the absolute number of malnourished people has gone up. Currently, over 350 million people are chronically malnourished. The crises of food insecurity in this region are related to low access rather than low availability. Food insecurity in Pakistan is a product of poverty and inadequate food availability. The term food poverty is commonly used to determine the level of poverty viz-a-viz food security in a country. During the past two decades, 1987-2007, food poverty incidence in the country shows that about one-third of the households were living below the food poverty line and they were not meeting their nutritional requirements. The incidence of food poverty is higher in rural areas (35 per cent), than in urban areas (26 per cent). Urban and rural areas, however, did not differ much in terms of calorie intake per capita, the differences across the four provinces were also not substantial.

Table 5 shows that about half of the Pakistani population has extremely low access to food despite bumper wheat crops during the last 2-3 years. The worst hit areas are KPK and Balochistan province. The situation in Punjab is also not very encouraging where more than half of the districts have low access to food. This clearly demonstrates that abundant food does not automatically mean people have access. Access to adequate food depends upon household income and food prices. For instance, in India and Pakistan, despite an increase in the total food availability from 1980 to 1999, the incidence of poverty has gone up and in recent years it has been reached to alarming levels. At present, about one-third of the households in Pakistan are living below the income poverty line and are thus unable to meet their minimal nutritional requirements (HDC, 2002). The access to adequate food for all segments of the population also depends upon on the pattern of land holdings, income distribution and employment opportunities (Figure 5).

ACCESS TO FOOD BY RURAL POPULATION IN PAKISTAN

Access Zone	Punjab	NWFP	Sindh	Balochistan	Northern Areas	AJK	FATA	**Total**
DISTRICTS								
Extremely Low	5	17	6	15	5	1	7	**56**
Very Low	7	5	4	5	-	1	-	**22**
Low	6	-	4	5	-	2	-	**17**
Moderate	5	1	2	-	-	1	-	**9**
High	11	1	1	1	-	2	-	**16**
Total	**34**	**24**	**17**	**26**	**5**	**7**	**7**	**120**

An efficient distribution of food is as important as its production. Even in the presence of excess supply, inefficient distribution among different segments of the society may lead to inadequate consumption and under-nourishment. In order to secure adequate food for the low-income groups, government should encourage food aid, food subsidies and low cost rationing programs. These programs have not been very successful in the past due to their cost and wrong targeting. The price supports and regulations mostly favored consumers and harmed producers, which depressed the production of domestic food.

The intra-household food security in Pakistan is usually dictated by traditions, with women eating's last and the least amount of food that is available to a household. The gender disparity in access to good food is evident from the fact that about 550 million women live below the poverty line (60 % of the world's rural population). This represents a 50% increase for women over the past 20 years, compared with a 30 % increase for men (IFPRI, 1995). The gender bias in access of food is mostly due to perceived differences in social and economic benefits that families supposed desire from boys and girls.

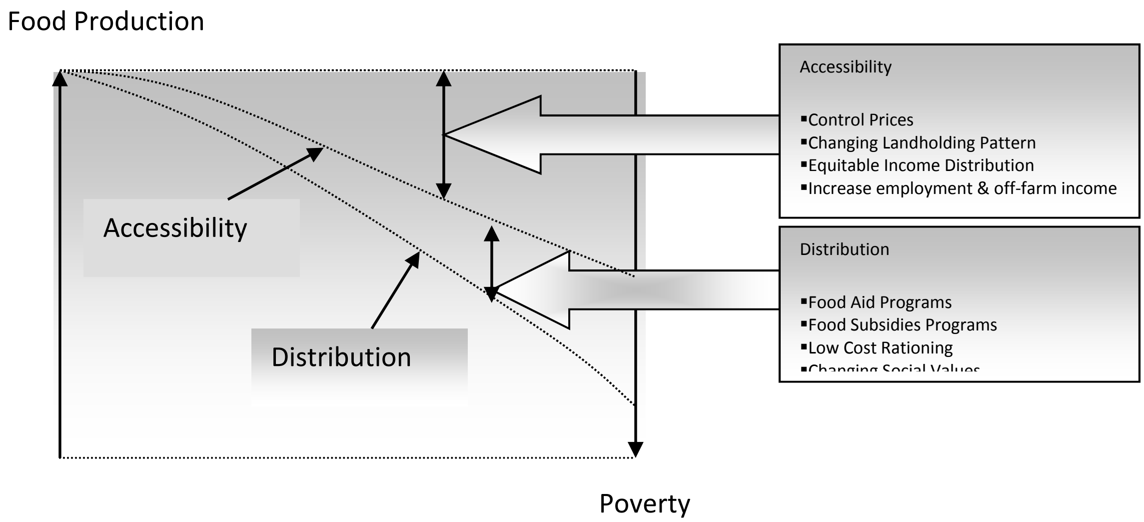

Figure 5: Poverty reduction trend with food accessibility and distribution

Conclusions

Irrigated agriculture is a vehicle for the reduction of vulnerability to food security. For sustainable food security, food production should be increased in a sustainable way. There are interventions, which can help the smallest producers improve their livelihoods and contribute to future food production.

- *Continued investments and extending participatory approach* in irrigation will be central to future food production. Strategy to investment in irrigation is key element to increase food production and maintain stable food prices.
- *Involvement of small-scale farmer's* support is needed to improve management and institutional structures so that poor smallholders benefit from reliable water supplies. Moreover the *initiatives that involve the landless* gaining access to the benefits of irrigation require greater exposure. New concentrations of the poor in peri-urban areas and regions where water resources are scarce and risk-prone need to be targeted.
- *Technology affordable and easy to maintain and operate* through which equitable water distribution system especially in difficult and marginal areas, where the poorest live needed much more attention in order to alleviate poverty.

Effective water governance should be a priority action to resolve the complex challenges in the water sector. We have the knowledge and tools to increase irrigation efficiency, reduce losses and save more water in the agricultural sector. By improving the productivity of water in irrigated agriculture, we can have more production in food with less need to expand irrigated area. In a broad sense, increasing water productivity in agriculture contributes not only to the overall food security equation but also to water security.

Rain-fed agriculture is often ignored in the water and food security puzzle. There are number of water harvesting techniques, groundwater use, storage and water application practices that can be used by smallholder farmers of the rain-fed areas. Development of drought resistance crop varieties, frequent tillage practices to conserve water (fallow) and low cost technologies or simple water harvesting structures to provide access to water at the critical growth stages of the growing crops are few practical options for these areas. Supplementary irrigation with freshwater and even with low quality and saline or treated waste water at the critical growth stages of cereals and, particularly at the flowering and seed filling stages

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