A Study on Dwindling Agricultural Water Availability in Irrigated Plains of Pakistan and Drip Irrigation as a Future Life Line

Muhammad Aamir Iqbal and Asif Iqbal

Department of Agronomy, Faculty of Agriculture, University of Agriculture Faisalabad-38040, Pakistan

Abstract: Agriculture constitutes the backbone of Pakistan’s economy by contributing 21.4% to national gross domestic product. 74% of cultivated area is irrigated (14.6 million hectares), out of 22 million hectares. Per capita water availability in Pakistan is continuously on decline as it stood at 1000 cubic meter per person per year in 2012-13, against 5600 cubic meter per person per year at the time of partition. Agricultural water availability is dwindling with each passing year, particularly due to reduction in Pakistan’s water storage capacity, increasing population and climate change. Pakistan owns world’s largest irrigation system as total length of canals in Pakistan is 56073 km, while the total length of water courses is 1.6 million km. About, 106 million acre feet water is diverted to canals, of which about 15% is lost in main and branch canals, 8% water is lost in distributary minors and 30% water is lost in water courses and 30% in the field, thus making the efficiency of irrigation system just over 41%. Drip irrigation also known as trickle irrigation which involves dripping water onto the soil at very low rates (2-20 liters per hour) constitutes the future life line for Pakistan’s irrigated agriculture. But high initial cost in the range of Rs.110000-120000 per acre and lack of awareness has hampered the adoption of this technique. Government needs to shoulder the responsibility by subsidizing the initial cost for drip irrigation to ensure the food security of teeming millions in times to come.

Key words: Food security • Micro-Irrigation • Pressurized irrigation • Row crops • Trickle irrigation

INTRODUCTION

Pakistan is an agricultural country with an area of 21.4 million hectares under cultivation, of which more than 74% of area is irrigated (14.6 million hectares) [1]. Pakistan is ranked at 4th position in terms of largest irrigated area worldwide and that too with world’s biggest canal irrigation network [2]. Irrigated agriculture is totally dependent upon fresh water resources for successful cultivation of crops. The total volume of water on earth is about 1.4 billion km$^3$ (cubic kilometers). The volume of fresh water resources is around 35 million km$^3$, or about 2.5 percent of the total volume. Of these freshwater resources, about 24 million km$^3$ or 70 percent is in the form of ice and permanent snow cover in mountainous regions, the Antarctic and Arctic regions. Around 30 percent of the world’s freshwater are stored underground in the form of groundwater (shallow and deep groundwater basins up to 2000 meters, soil moisture, swamp water and permafrost). This constitutes about 97 percent of all the freshwater that is potentially available for human use. Freshwater lakes and rivers contain an estimated 105 000 km$^3$ or around 0.3 percent of the world’s freshwater [2]. The total usable freshwater supply for ecosystems and humans is about 200 000 km$^3$ of water which is less than 1% of all freshwater resources. Pakistan’s surface flow in the Indus basin system is 145 MAF annually. However, the Western streams that flow basically during the monsoons bring 5 to 10 MAF annually, depending on the wet or dry cycles. It seems that the water mined from underground aquifers, which is around 40 MAF annually, is not really a renewable resource. Pakistan is sprinting from a water scarce country to becoming a water stressed country and within a decade, a water famine country. Pakistan’s per capita availability of water has declined from 5600 cubic meters
in 1947 to 1200 cubic meters in 2005 and now it is quickly approaching the threshold level of 1000 cubic meters against water threshold of 1,800m$^3$ per capita. The per capita water availability in the USA was 6,000 cubic meters, in Australia 5,500 cubic meters and in China 2,200 cubic meters in 2013. Water availability across our part of the world is already unpredictable due to climate change with a simultaneous increase in major flooding and severe droughts. It has been estimated that shrinking Himalayan glaciers will reduce the flow of water to the Indus river by around 8 over the next four decades. Unlike most developing countries of the world, where according to latest estimates 70 to 80 percent of fresh water resources are used for agriculture purposes, Pakistan consumes up to 98 percent of its fresh water resources for agriculture. This trend of water consumption in Pakistan, over the last ten years, has been on the rise.

So this study provides a comprehensive overview of the current agricultural water availability in irrigated plains of Pakistan and suggests solutions and feasibility of drip irrigation as an alternate to other prevalent irrigation techniques to make sure the sustainability of irrigated agriculture.

**MATERIALS AND METHODS**

In this study, the data pertaining to the cultivated area in irrigated plains of Pakistan, current irrigated water scenario and drip irrigation technique and its economics, were collected from Economic survey of Pakistan [1], Food and Agriculture Organization [2], different related scientific articles and interviews with farmers during June 2011 to September 2011 were carried out regarding the economics of drip irrigation and abiana (cost paid by farmer for canal water).

**RESULTS AND DISCUSSION**

Present Inefficient Irrigation System of Pakistan:
The Indus Basin Irrigation System consists of 16 barrages, 3 major reservoirs, 2 head-works, 2 siphons across major rivers, 44 canal systems, (23 in Punjab, 14 in Sindh, 5 in KPK and 2 in Balochistan), 12 inter river link canals and more than 107,000 water courses. The total length of canals in Pakistan is 56073 km, while the total length of water courses is 1.6 million km. About, 106 MAF (million acre feet) water is diverted to canals [1], of which about 15% is lost in main and branch canals. So 90 MAF reaches the distributary minors where about 8% water is lost (7 MAF). 83 MAF is reached in water courses and about 30% water is lost (25 MAF) during flow in water courses. Thus only 58 MAF water is available at field head and 30% water (17 MAF) is lost in field mainly due to flood irrigation. In this way, only 41 MAF water is utilized properly out of 106 MAF that is diverted to canal network. In real sense, the efficiency of our irrigation system is only 42-45%. This grim situation is the outcome of the fact that there is no general consensus in country about the strategies to be evolved for resolving the issue of water shortage. As a result, no major water reservoirs have been built in the country for a long time. Besides this, the storage capacity in the old water reservoirs is also decreasing with the passage of time. At the time when Tarbela, Mangla and Chashma Dams were built in Pakistan, the country's water storage capacity was 15.74 million acre feet, which has reduced to 12.10 million acre feet by the year 2012. Precious water is running out very quickly and being lost in Arabian Sea. The existing live storage capacity of dams is hardly 12 MAF or less than 10% of average annual river flow in Pakistan. Due to excessive sediment inflows in the river water, all the three existing storages (Tarbela, Mangla and Chashma) are rapidly losing their capacities and this loss is one MAF in six years. Tarbela dam has lost 32 per cent water storage capacity, as its original live water storage was 9.69 MAF, while its present live water storage is 6.56 MAF. Chashma Dam had lost its full capacity and present live storage of the dam was 0.26 MAF from 0.72 MAF and water storage capacity loss of the dam was 64%. By the year 2025, these dams would have lost 37 per cent of their water storage capacity. It means that their water storage capacity would be reduced by 6.27 million acre feet by that time. If nothing is done, there would be approximately 18% shortfall in irrigation water supply and 1,457 MW in electricity supply, crippling agriculture, industry, business and daily life. The role of sweet water also is central to the country’s financial sustainability and survival. Figure 1 reveals the fact that in 1947, per capita water availability was 5600 cubic meter person$^{-1}$ year$^{-1}$ and in 2013 it reduced to 1000 cubic meter person$^{-1}$ year$^{-1}$. Punjab being the food basket of Pakistan takes about 30-34 MAF (million acre feet) during spring season and Sindh withdraws around 25-29 MAF of canal water (Figure 2), while during fall or autumn season, Punjab takes canal water in the range of 13-17 MAF and Sindh withdraws 10-13 MAF during the fall season (Figure 3).
Fig. 1: Per capita water availability in Pakistan (cubic meters per person per year).

Fig. 2: Province-wise withdrawal of canal water (million acre feet) during spring season.

Fig. 3: Province-wise withdrawal of canal water (million acre feet) during fall season.
Future Life Line for Agriculture: The canal irrigation system, some part of which is over 100 years old, is unsustainable unless a system can be devised for the pricing of water to finance the maintenance of the system. Currently, the irrigation system recovers only 24 percent of the annual cost of overhaul and maintenance and requires an annual subsidy of Rs5.5 billion. As the system ages so the cost of maintaining it rises. The irrigation system is functioning below par because the current Abiana recovery rate is 60 percent nationally and still declining rapidly, while the canal-irrigated areas remain the same in terms of acreage. The price of canal water has not kept pace with that of other commodities over the years. The price farmers pay for water, the abiyan, fluctuates between Rs85 per cropped acre in Punjab to Rs.250 per acre for non-food crops in Khyber Pakhtunkhwa. These rates and the rate of collection of abiyan by provincial irrigation departments, do not cover the operation and maintenance costs of the irrigation system, let alone costs of repair, maintenance and development. In no way, the current pricing system is sustainable. It is a misperception that Pakistan does not have enough water. The fact is that Pakistan does not have enough reservoirs to store water and thus majority of it flows down the Arabian Sea (about 36 MAF). The country, unlike the European and other western countries, is not a recipient of rain throughout the year. The rain comes in heavy spells in the monsoon season, causing floods in more than quarter of the country and eventually gets sacrificed to the Arabian Sea after creating havoc in agricultural capitals. This would not have been the case if Pakistan would have enough reservoirs. The reservoirs can be used to generate electricity and irrigate the arid areas of the country and in turn strengthening the agricultural backbone of the country. The ground water level will also rise, thus increasing the efficiency of the tube wells and they will be used as and when required. Another thing that masses in irrigated plains of Pakistan do not realize is the fact that tube wells are a temporary, expensive and unreliable solution to supplement the water requirement of crops in addition to the river water used to the fullest with the help of this technique. Modern drip irrigation also known as trickle irrigation which involves dripping water onto the soil at very low rates (2-10 liters/hour) has arguably become the world's most valued innovation in agriculture since the invention of the impact sprinkler in the 1930s, which offered the first practical alternative to surface irrigation [4]. Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters
[5]. Subsurface drip irrigation (SDI) uses permanently or temporarily buried dripper-line or drip tape located at or below the plant roots. Other major components of drip irrigation system include a pump or pressurized water source to pump the water from water source into the pipes system [6]. A pressure control valve (pressure regulator) in the drip system maintains the continuous and constant pressure of water flow in the system. The pumped water passes through the water filter or filtration systems which includes sand separator in the form of hydrocyclone, screen filters, media filters or disk filters to separate different particles. Then water enters into the fertigation system (venturi injector) and chemigation equipment (optional). A backwash controller (backflow prevention device) is put to prevent backward flow of water in the system. Main line (larger diameter pipe and pipe fittings) are buried in soil or kept on soil for crops sown in rows, fitted with smaller diameter poly-tube (often referred to as laterals) and emitting devices near plants (emitter or dripper, micro spray head, inline dripper or inline drip-tube). Drip irrigation technology ensures that fertilizer and nutrient loss is minimized due to localized application and reduced leaching [7-11]. The biggest advantage of drip irrigation is that water application efficiency is high as an acre can be irrigated in 15-25 minutes depending upon the crop and soil type, despite the fact that field leveling is not necessary and fields with irregular shapes are easily accommodated [12, 13 & 14]. Recycled non-potable water can be safely used with drip irrigation system and crops can be grown in areas where other traditional irrigation methods do not work [15-18]. Drought which reduces the crops yield in the range of 20-80% can be prevented this irrigation technique as moisture within the root zone can be maintained at field capacity. Soil erosion is lessened by drip irrigation technique, in complete contrast to flood irrigation as prevalent in Pakistan. Weeds growth is also lessened by trickle irrigation system as water is not applied to whole field, rather to only root zone of the crops sown in rows and as a result weeds infestation is reduced to a greater extent. Drip irrigation system ensures that water distribution is highly uniform which is controlled by output of each nozzle [19 & 20]. Labor cost in drip irrigation method is less than other irrigation methods [21]. Another advantage associated with drip irrigation is that variation in supply can be regulated by regulating the valves and drippers [22, 23 & 24]. Fertigation can easily be included with minimal waste of fertilizers and fertilizer use efficiency which is the percent recovery of applied nutrients in the harvested portion of crops as stated by soil scientist or percent increase in the yield with a unit of applied fertilizer [25]. As drip irrigation supplies water in the root zone of plants only and as a result foliage remains dry, reducing the risk of disease, particularly the fungal diseases that tend to attack crops in moist conditions. Drip irrigation system is operated at lower pressure [26, 27, 28 & 29], which minimizes energy use than other types of pressurized irrigation techniques such as sprinkler irrigation in which water is applied as rain in the form of drizzling fountain [30, 31, 32 & 33]. However, there are some disadvantages that are associated with this technique and the biggest one is that of high initial cost that is in the range of Rs.110000-120000 per acre and looking at the economic condition of farmers in Pakistan, it would be only a day dream to expect adoption of this technique in Pakistan. Only government can shoulder the responsibility to ensure food security for teeming millions by providing subsidy and giving provincial agriculture departments the task to make farmers aware of this technique and providing the system at subsidized rates. For this, federal and provincial governments can make arrangements by providing a portion of subsidy before it becomes the matter of too little, too late. Another technical problem with system is that the sun can affect the tubes used for drip irrigation, shortening their usable life and solution for this can be wheat or rice straw that should cover the pipes and has the potential to prevent the direct striking of sun rays on pipes. Farmers should be made aware of the fact that if water is not properly filtered and the equipment not properly maintained, it can result in clogging. Farmers are also needed to be made aware of the time that is required for water application with drip irrigation system and extensive research on different crops needs to be done related to subsurface drip system as the irrigator cannot see the water that is applied. This may lead to the farmer either applying too much water (low efficiency) or an insufficient amount of water and this is particularly common for those with less experience of drip irrigation. The drip irrigation technique can lead to waste of water, time and harvest, if not installed properly. These systems require careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions and suitability of drip irrigation system and its components. In lighter soils, subsurface drip may be unable to wet the soil surface for germination, so in lighter soils, careful consideration of the installation depth is required. The main purpose of drip irrigation is to reduce
the water consumption by reducing the leaching factor. However when the available water is of high salinity or alkalinity, the field soil becomes gradually unsuitable for cultivation due to high salinity or poor infiltration of the soil. Thus drip irrigation converts fields in to fallow lands when natural leaching by rain water is not adequate in semi-arid and arid regions and this problem can be solved with occasional flood irrigation to make the salts leach down the soil. In Pakistan, economics is the major factor that has hindered the adoption of this technique on wide scale. Another important factor is the lack of awareness and knowledge about the benefits associated with drip irrigation technique. It will be the government seriousness that will determine the scale and degree of adoption of this technique, because without heavy subsidy, small and even medium farmers cannot adopt this technique on their own.

CONCLUSION

Irrigated agriculture provides the major chunk of food, feed and fiber in Pakistan and to make the irrigated plains productive on sustainable basis in the wake of emerging dooming water scenario due to climate change and other factors, drip irrigation holds the key. Federal as well as provincial governments have to shoulder the responsibility by providing subsidy for the installation of drip irrigation system and for this; a substantial amount from the budget must be set aside as installation cost of Rs.110000-120000 per acre is too high for already economically suffering farming community. Provincial agriculture departments also have the responsibility to educate the farmers about the benefits associated with drip irrigation. Last but not least, the agronomists, engineers and researchers need to strive for excellence in drip irrigation technology, keeping in view the soil, water resources, climatic conditions and economics of farming community to ensure food security for each and every human. The need of hour is to move away from blaming the global warming, floods and water shortages and concentrate to make the best use of available water resources by adopting drip irrigation in place of flood irrigation method.

REFERENCES