COPING WITH WATER SCARCITY THROUGH MICRO-IRRIGATION

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Abstract

The agriculture sector is the predominant consumer of water. Almost 70% of all available freshwater is used for agriculture across the world. Agriculture is responsible for most of the depletion of groundwater, along with up to 70% of the pollution. Many of the world’s most important grain lands are consuming groundwater at unsustainable rates. As we have stepped into the twenty first century, the new frontier is boosting water productivity, getting more from every liter of water devoted to crop production. There is long and growing list of measures that can increase agricultural water productivity. Drip irrigation ranks near the top of measures and can achieve efficiencies as high as 95 percent, compared with 50-70 percent for more conventional flood or furrow irrigation. Microirrigation reduces the virtual water requirement of the agricultural products thus improving water use efficiency. Government of Andhra Pradesh has launched the Andhra Pradesh Microirrigation Project (APMIP) in 2003 to promote microirrigation in large scale. The project has so far covered more than 4.34 lakh ha area under microirrigation systems in 5 years period and helped in improving the crop productivity, saving in water and energy and creating employment opportunities. Automation, fertigation, post harvest management and marketing are the areas of importance for bringing sustainability.

Key words: Water Scarcity, Virtual Water, Sustainable Development, Microirrigation,

Introduction

Although water is the most widely occurring substance on Earth, only 2.53% (35 million km$^3$) of it is fresh water. The remaining 97.47% (1,365 million km$^3$) is saltwater. Of the small amount of freshwater, only one third is easily available for human consumption, the large majority being locked up in glaciers and snow cover.

Imbalances between availability and demand, the degradation of groundwater and surface water quality, intersectoral competition, interregional and international conflicts, all bring water issues to the fore. Most countries in the Near East and North Africa suffer from acute water scarcity, as do countries such as Mexico, Pakistan, South Africa, and large parts of China and India. Irrigated agriculture, which represents the bulk of the demand for water in these countries, is also usually the first sector affected by water shortage and increased scarcity, resulting in a decreased capacity to maintain per capita food production while meeting water needs for domestic, industrial and environmental purposes. In order to sustain their needs, these countries need to focus on the efficient use of all water sources (groundwater, surface water and rainfall) and on water allocation strategies that maximize the economic and social returns to limited water resources, and at the same time enhance the water productivity of all sectors.

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**Rise in Water Usage**

Water is intrinsic to our lives and to the ecosystems on which we all depend. Water is essential to life in every way, we need clean water for drinking, adequate water for sanitation and hygiene, sufficient water for food and industrial production, and much of our energy generation relies on or affects water supplies. World's water usage pattern in the previous century, which is growing at alarming rate, is shown in Fig 1.

![Chart showing water usage pattern](chart.png)

**Fig.1 World’s water use pattern in 20th century**

Urban areas place heavy pressure on neighboring water resources. Water use has been growing at more than twice the rate of population increase in the last century (Fig 1), and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water. By 2025, 1,800 million people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under stress conditions. The situation will be exacerbated as rapidly growing water use.

**Virtual Water**

The concept of virtual water links a large range of sectors and issues that revolve around relieving pressures on water resources, ensuring food security, developing global and regional water markets.

The concept of virtual water emerged in the early 1990s and was first defined by Professor J.A. Allan as the water embedded in commodities. Producing goods and services requires water; the water used to produce agricultural or industrial products is called the virtual water of the product.

Virtual water is an essential tool in calculating the real water use of a country, or its water footprint, which is equal to the total domestic use, plus the virtual water import, minus the virtual water export of a country. A nation’s water footprint is a useful indicator of the demand it places on global water resources. By importing virtual water, water poor countries can relieve the pressure on their domestic water resources.
At the individual level, the water footprint is equal to the total virtual water content of all products consumed. A meat diet implies a much larger water footprint than a vegetarian one, at an average of 4,000 liters of water per day versus 1,500. Being aware of our individual water footprint can help us use water more carefully. Virtual water of some of the important products is shown in the Table 1.

Table 1. Virtual water of some important products

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Virtual water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cup of coffee</td>
<td>140 liters</td>
</tr>
<tr>
<td>1 liter of milk</td>
<td>800 liters</td>
</tr>
<tr>
<td>1 kg maize</td>
<td>900 liters</td>
</tr>
<tr>
<td>1 kg of wheat</td>
<td>1100 liters</td>
</tr>
<tr>
<td>1 kg of rice</td>
<td>3000 liters</td>
</tr>
<tr>
<td>1 kg sugar</td>
<td>3200 liters</td>
</tr>
<tr>
<td>1 kg of poultry</td>
<td>6000 liters</td>
</tr>
</tbody>
</table>

Adopting a virtual water strategy: a solution for water-poor countries

Importing of virtual water (via food or industrial products) can be a valuable solution to water scarcity, especially for arid countries that depend on irrigation to grow low-value food with high water needs.

For example, growing one tonne of grain or wheat requires about 1,000 m$^3$ of water; growing the same amount of rice requires up to thrice as much. The value of the water used for producing these food staples in water-poor countries turns out to be many times higher than the value of the product. Thus, instead of using their scarce water resources for water-intensive products, such countries can import cheap food, and relieve the pressure on their own water resources.

Sustainable Development

The World Commission on Development (known as Brundtland Commission) in 1987 coined a term ‘Sustainable Development’ and defined as ‘Development that meets the need of the present without compromising the ability of the future generations to meet their own needs’.

International Conference on Water and Environment (ICWE) held in Ireland in 1990 indicating the importance of water for sustainable development has made the following recommendations (Dublin Principles)

1. Freshwater is a finite vulnerable resource, essential to sustain life, development and environment
2. Water development and management should be based on a participatory approach involving users, planners and policy makers at all levels
3. Women play a central part in the provision, management and safeguarding of water.
4. Water has an economic value in all its competing uses and should be recognized as an economic good.

Water For Agriculture

Almost 70% of all available freshwater is used for agriculture (Table 2). Over pumping of groundwater by the world's farmers exceeds natural replenishment by at least 160 billion cubic meters a year. It takes an enormous amount of water to produce crops: three cubic meters to yield just one kilo of rice, and 1,000 tons of water to produce just one ton of grain. Land in agricultural use has increased by 12% since the
1960s to about 1.5 billion hectares. Current global water withdrawals for irrigation are estimated at about 2,000 to 2,555 km³ per year.

Table 2. Comparison of water usage in different sectors

<table>
<thead>
<tr>
<th>Usage in (%)</th>
<th>World</th>
<th>Europe</th>
<th>Africa</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>69</td>
<td>33</td>
<td>88</td>
<td>82</td>
</tr>
<tr>
<td>Industry</td>
<td>23</td>
<td>54</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Domestic use</td>
<td>8</td>
<td>13</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

Agriculture is responsible for most of the depletion of groundwater, along with up to 70% of the pollution. For the last half-century, agriculture’s principal challenge has been raising land productivity- getting more crops out of each hectare of land. As we have stepped into the twenty first century, the new frontier is boosting water productivity getting more from every liter of water devoted to crop production. There is long and growing list of measures that can increase agricultural water productivity.

Microirrigation

Microirrigation ranks near the top of measures with substantial untapped potential. In contrast to a flooded field, which allows a large share of water to evaporate without benefiting a crop, drip irrigation results in negligible evaporation losses. When combined with soil moisture monitoring or other ways of assessing crop’s water needs accurately, drip irrigation can achieve efficiencies as high as 95 percent, compared with 50-70 percent for more conventional flood or furrow irrigation. In Microirrigation water is carried through small tubing and delivered to the plant near its stem to meet its water requirement. India with 8.5 lakh ha of drip irrigated area stands third in the world, next to USA and Spain. In terms of percentage of area covered under drip irrigation Israel with 74% stands first.

A National Task Force Committee, appointed by the Govt of Inida in 2003, has recommended that 69 million ha area is suitable for microirrigation in India. A target of 14 M ha has been suggested for the 11th five-year plan. In view of the various advantages the technology offers, today the Govt of India and number of state governments are keenly focused in promoting microirrigation in large scale.

AP Microirrigation Project

Realizing the importance for economic use of precious ground water for irrigation, Government of Andhra Pradesh has launched the Andhra Pradesh Microirrigation Project (APMIP), first of its kind in the world on 3rd November 2003. The project was aimed at bringing 2.50 lakh ha area under microirrigation systems in 22 districts of AP, with financial outlay of Rs. 11763 million.

Project Implementation

Implementing agencies have been setup at state level and district level for discussing policy issues and for implementation of the project. At state level the Commissioner of Horticulture implements the program under the chairmanship of APC & Principal Secretary. All policy decisions are taken up in the standing committee, which comprises the heads of line departments, officers and experts from various institutes. Technical committee examines all issues and recommends to the standing committee. A state level senior official heads the project as Project Officer supported by five senior officers of different disciplines. The state level organizational setup is shown in Fig 2.
At district level the District Collector acts as the chairman of the project. The Project Director, APMIP heads the project. One Assistant Project Director, a senior officer from Agriculture/Horticulture/Sericulture departments, acts as the Nodal Officer. For technical support two Microirrigation Engineers are placed in each district to examine the survey reports, designs, and BOQs and they also carryout field inspections. For providing agri-extension services and capacity building a core team comprising of two Agronomist/Horticulturist are provided. At mandal level MI Area Officers are placed for providing services to the farmers.

**Initiatives of the Government**

Govt of AP has taken up number of measures for promoting microirrigation, like i) 70% subsidy of the system cost, ii) Creation of separate project cells in the districts iii) Positioning of qualified technical persons, iv) organizing exposure visits and capacity building training programs, v) guarantee of the MI equipment against manufacturing defects, vi) Quality check of equipment through CIPET, vii) Monitoring and Evaluation through third party agencies and viii) Providing agronomic and extension services. These measures have helped in confidence building and lead to greater demand for micro irrigation in the state.
Progress of APMIP

The project has created national record during last four successive years by bringing highest area under micro irrigation in the country as shown in the table 3.

Table 3. Coverage of MI systems since inception of APMIP

<table>
<thead>
<tr>
<th>Year</th>
<th>Area covered under microirrigation, ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sprinkler</td>
</tr>
<tr>
<td>2003-04</td>
<td>20,770</td>
</tr>
<tr>
<td>2004-05</td>
<td>40,020</td>
</tr>
<tr>
<td>2005-06</td>
<td>25,000</td>
</tr>
<tr>
<td>2006-07</td>
<td>23,750</td>
</tr>
<tr>
<td>2007-08</td>
<td>29,534</td>
</tr>
<tr>
<td>2008-09</td>
<td>17,953</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,57,493</strong></td>
</tr>
</tbody>
</table>

Table 4. Additional monetary benefits due to drip irrigation for sugarcane in 9,600 ha

<table>
<thead>
<tr>
<th>Item</th>
<th>Surface method</th>
<th>Drip method</th>
<th>Saving/Increase</th>
<th>Unit value</th>
<th>Amount, Rs. million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>21,120 ha-m</td>
<td>9,600 ha-m</td>
<td>11,520 ha-m</td>
<td>Rs. 2000/-per ha-m</td>
<td>23.04</td>
</tr>
<tr>
<td>Energy</td>
<td>24.24 million kwh</td>
<td>11.136 million kwh</td>
<td>13.08 million kwh</td>
<td>Rs. 2/-per kwh</td>
<td>26.16</td>
</tr>
<tr>
<td>Yield</td>
<td>7,87,200 ton</td>
<td>12,57,600 ton</td>
<td>4,70,400 ton</td>
<td>Rs. 1,000/-per ton</td>
<td>470.40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>519.6</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Microirrigation Pays

Implementation of APMIP has created great awareness among the farmers in the state about microirrigation. Large number of farmers have realized the benefits of microirrigation in terms of improvement in yields, water saving and reduction of labor requirement. In order to assess the impact of the project more than 500 case studies of various crops have been collected from the districts across the state.

Effect Of Mi In Sugarcane

A sample analysis carried out on 12 cases of sugarcane has revealed that additional income of about Rs 47,000 per ha was obtained due to higher cane yield. By considering average cost of MI system as Rs 65,000 per ha the bay back period comes to 1.4. APMIP has covered 9,600 ha of sugarcane crop under drip systems till March 2007. Based on the inputs received from the field studies, the projected benefits are worked out and presented in Table 4. With certain assumptions the energy requirement for pumping is estimated that 2,525 kwh and 1,160 kwh of electricity is required for irrigating one ha area under surface and drip methods respectively. This indicates that for every hectare of sugarcane crop with drip system
there would be a saving of 1.2 ha m of precious ground water and 1,365 kwh energy in comparison to surface method of irrigation.

The projected benefits due to microirrigation in sugarcane crop in 9600 ha indicates that there would be a saving of 9,696 ha m of precious ground water, and 11.03 million units of electricity every year apart from 0.470 million tons of additional cane. These additional benefits converted into monetary terms are equivalent to Rs. 519.6 million.

Additional income generated through drip for sugarcane divided by the annual cost gives the net benefit derived per every rupee investment in sugarcane. It shows, that every rupee spent on drip system for sugarcane results in additional benefit) of Rs. 4.05

**Overall impact of APMIP**

The overall impact of APMIP has been summarized to present impact of implementation as detailed below.

I. Total Area Covered : 4.34 lakh ha
   a) Drip : 2.77 lakh ha
   b) Sprinkler : 1.57 lakh ha

II. MI system cost
   a) Total : Rs 1312 crores
   b) Farmers contribution : Rs 460 crores

III. Annual cost (CRF 0.2055) based on
   a) Total cost : Rs 270 crore
   b) Farmers contribution : Rs 95 crores

IV. Additional yield
   @Rs 15,000/ha minimum : Rs 651 crores

V. Payback period based (II/IV)
   a) Total cost : 2.0 years
   b) Farmers contribution : 0.7 years

VI. Every rupee on MI yields (IV/III)
   a) Total annual cost : Rs 2.4
   b) Farmers annual cost : Rs 6.9

In addition to the direct benefit of yield increase, the project also helped in  a) water saving of 1.75 lakh ha-m, b) Energy saving of 175 million kwh, c) large labour saving and d) employment generation.

**Microirrigation In Canal Commands**

In order to extend the benefits of microirrigation to the farmers of canal commands of major lift projects, the Govt of AP has commenced a new project called LIMIP to bring 8 lakh ha area under microirrigation. Guidelines and designs are finalized and the pilot projects are under execution in Nalgonda and Kadapa districts. In LIMIP the water from the canal will be drawn to the sump and from there it will be delivered to the individual farm with required pressure and discharge. The operating time of the system will depend upon the power availability at farm level, which is 7 hrs a day. The layout of the system is shown in fig 3.
Future needs

Based on the experiences in APMIP, the following are the areas to be considered seriously to attain sustainability in microirrigation.

a) Creation of Microirrigation Department at state level
b) Bankers participation to fund the farmers share of cost of MI systems
c) Qualified and trained manpower is required for both the industry and the projects.

d) Standardization of imported MI equipment is needed

Summary And Conclusions

The world and more importantly the developing countries are heading towards water stress and scarcity. They are left with no alternative but to adopt modern irrigation technologies, which save water, double the area under irrigation, improve yields and quality as well as save on labour, energy and crop production costs. In India more than 82% of the total water is used for agriculture with very low irrigation efficiencies. It is expected that in the next 7-8 years, there will be cut of about 10%
irrigation water for meeting ever-increasing demand from domestic, industrial and other sectors. Hence, there is necessity to undertake large-scale microirrigation projects like Andhra Pradesh Microirrigation Project (APMIP) to bring more areas under drip irrigation systems improving water use efficiencies to as high as 95%. The following conclusions can be drawn

1. The beneficiaries have realized the benefits of microirrigation in terms of water saving, higher yields and reduction in labor requirement.
2. Many state governments are showing interest to implement such projects in their states. Gujarat government is one, which has got benefited from the experience of APMIP and has already implementing a project on microirrigation on similar lines of APMIP.
3. Large-scale implementation of such projects will lead to saving of precious water resources, saving energy and improving the productivity.
4. The average pay back period comes to 2.0 years with overall system cost as the basis and by considering farmers contribution it comes to 0.7 years only.
5. Every rupee invested in microirrigation on annual basis yields additional income of Rs 2.4 due to additional crop yield.

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