Micro-Irrigation for Sustainable Agriculture

A Handbook for Farmers

Hanns
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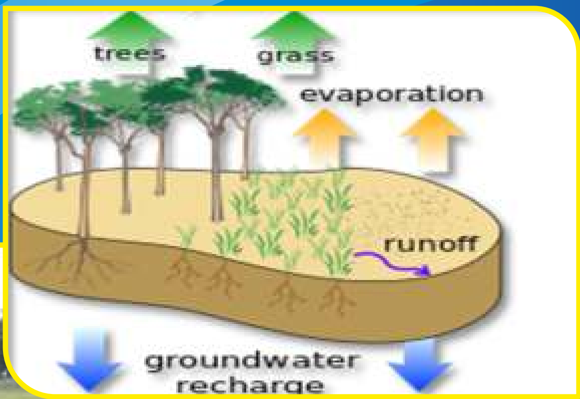

August 2023

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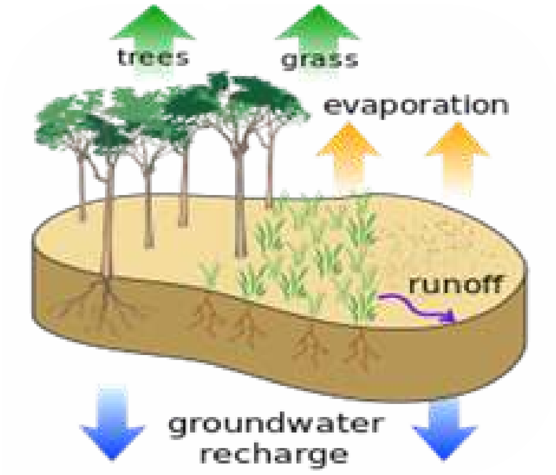

Hanns Seidel Stiftung

INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE
ISEC

August 2023

Institute for Social and Economic Change

(An all India Institute for inter-disciplinary research and training in the social sciences)

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Professor D. Rajasekhar

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Foreword From Director, ISEC

Ever Since the establishment of the Institute for Social and Economic Change (ISEC) in 1972, the Agricultural Development and Rural Transformation Centre (ADRTC) has been undertaking several research studies concerning with farmers and their welfare. The findings of all the research studies have been made available to the government for policy making. In addition, action research is also undertaken in the farming sector about the problems confronted. In this research, undertaken at the ADRT Centre the findings of research in the field were shared with the farmers in a workshop. The findings in the workshop are reported here.

I am happy to know that ADRTC is sharing findings of its research on micro irrigation to farmers another workshop will be organized in the first half of September 2023. I am also pleased to learn that in ADRTC has been involving other field based experts this research involving interaction with farming community in addition to its own staff. Thus, it is an ideal combination of academic and field based research efforts moving in cohesion for the making Indian agriculture as sustainable and economically viable.

I take this opportunity to thank Dr. Susheela, B. IAS, Deputy Commissioner, district administration of Yadgir district, the other line departments for extending their full support for making the research efforts bear fruits and the farmers who shared their views whole heartedly.

I hope such interactions would reduce the distance between field to farmer and provide farming community to assimilate the knowledge generated.

Sd/-
D. Rajasekhar

Acknowledgment

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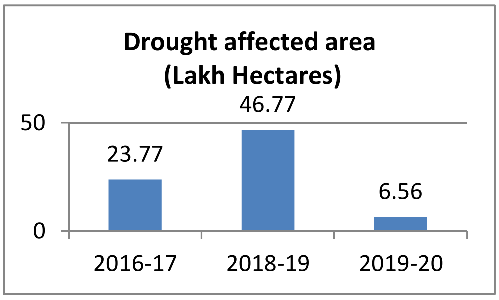
I. The Problem

Karnataka like many other states in India has agriculture as its major source of livelihood for its population. It is well documented that the State confronts the threat of frequent droughts with above 20% probability i.e., two years out of every decade are most likely the drought years (GoI, 1976). Every visitation of drought sets back the clock of development in many distressed regions and the consequent investment is cumulatively larger. Therefore, it is not surprising that Karnataka comes under the hotspots of agrarian distress with large number of farmer suicides. Agriculture in Karnataka always remained susceptible and farming community vulnerable to the adverse impacts of natural disasters. About 80 per cent of taluks (blocks) in the State are drought-prone ranging between 60 to 114 talukas confront drought over years (GoK, Drought Memorandum, 2023). According to the Ministry of Agriculture and Farmers Welfare (MoAFC&W), 16 districts of the state, mostly from North Interior Karnataka, have experienced drought for a period of 10 years during the last 18 years (2001 to 2018). It is known that districts in North Interior Karnataka region are more prone to the severe droughts aggravated by inadequate water sources results into perpetual dependence on monsoons. To add salt to injury, climate change projections have indicated that the regions that already witness less rainfall and higher temperatures, will further experience lesser rainfall and increase in average temperatures (SAPCC 2013). As a result, this region also confronts severe agrarian distress resulting into number of farmer suicides. Only a protective mechanism can save precious lives in this region. Impact of drought on low Human Development Indices (HDI) can be observed as the majority of the North Interior Karnataka districts, in comparison with other regions of the state. Two districts viz., Raichur and Yadgir, which are most vulnerable to droughts have been categorized as Aspirational Districts by the Niti Aayog (NITI 2018 a & b). These will require intensive policy attention.



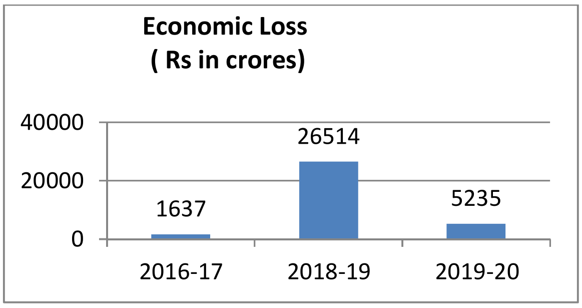
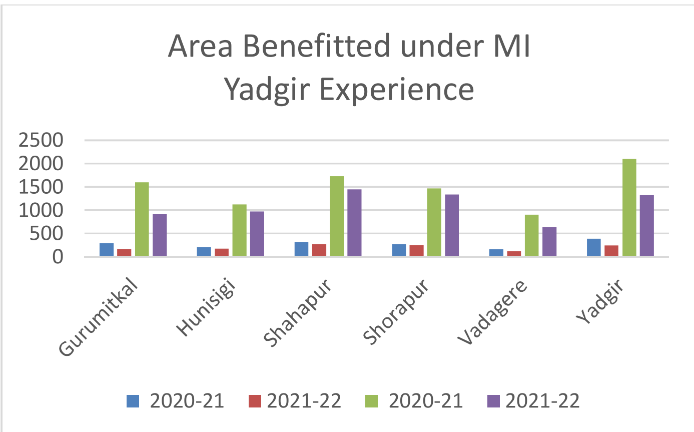


Fig: 1: Impact of Droughts on Karnataka Agricultural Sector (Take this above the Figure)

*Area affected= loss of sown area + area affected by disaster-Lakh ha. @Economic Loss = As per Cost of Cultivation in Crores Rs. Source: Memorandums submitted by GoK to GoI

Yadgir is one of the eternally drought affected district in this region. The district in the northern part of Karnataka between 16° 11' – 16° 50' N. latitudes and 76° 17' - 77° 28' E. longitudes, has a geographical area of 5234.4 sq. Km (Fig 2). It is predominantly an agricultural district divided into two agro-climatic zones namely eastern transition and northeastern dry zone, indicating the dependence on rain. According to the Drought Vulnerability Composite Index (DVI) based on the four indices (CI, CSI, CCI and LI), about 33 per cent under Class 4 of DVI and 67 per cent under very highly vulnerable class 5 (REFERENCE HERE). Normal Rainfall of the district is 699 mm but, from the year 2000, the district had drought conditions for 14 years. This factor has its impact on socioeconomic conditions with highest out-migration of agricultural labourers, small and marginal farmers to Bengaluru, Pune, Sholapur and and even to long distance cities. The literacy rate is 51.8 per cent while female literacy is at 41.8 per cent with 23.2 per cent of Scheduled castes and 12.5 per cent of Scheduled Tribes (Yadgir District At Glance 2019). Of the three taluks in the district, viz., Shorapur, Shahpur and Yadgir, Yadgir taluk has the lowest HDI (Yadgir District At Glance 2019).

It goes without saying that protecting the crops and ensuring assured yield are the priorities of the State. These twin objectives could be achieved by supporting the farmer through assured irrigation. Given the constraint on aggregate water availability (both surface and groundwater) this is feasible only through micro irrigation that is a hallmark of water use efficiency. In view of its vulnerability for drought, the State government, has initiated some new intercessions to reduce the adverse impacts of the drought. Micro Irrigation is one such intervention that offers twin benefits both high water use efficiency along with 'Protective Irrigation' if need arises. It could be an effective strategy to minimise the adverse effects of sub-optimal rain to some extent.



Area Benefitted under Micro Irrigation in Yadgir District

The most frequent visitations of drought along with its severe impact on the livelihood systems calls for an incisive policy attention.

Frequent droughts, destabilises all calculated measures, unless concerted efforts were made by all stakeholders. For instance, adoption of micro-irrigation solely depends on the groundwater as well as its recharge levels. Continuous withdrawal of groundwater under the traditional flood irrigation method, coupled with inadequate recharge would further reduce its availability. In such conditions, efficiency of micro-irrigation will help in case of continued drought conditions. However, if water use remains unabated and water guzzling crop pattern is followed the MI systems even may fail totally .

This study was undertaken to document and understand the efficiency of micro-irrigation under the given constraints with the help of Hanns Seidel Stifung, Germany. The findings of the earlier study are based on primary survey interviewing 120 farmers in Yadgir and Gurumitkal taluks of Yadgir district (core drought prone regions). The results indicated that most important stakeholders for sustainable drought proofing measures are a) farming community and b) concerned government officials and technical assistance. At farmers level, the study has pointed out that, if adequate attention paid to various aspects pertaining to micro-irrigation can enhance the efficiency and ensure long term sustainability.

II Why Groundwater Table is Receding?

Around 70 per cent of irrigation in India is from groundwater. Added to this the construction activities, roads and some development initiatives are blocking the traditional recharge zones without any replacements. Hence, recharge of groundwater becomes crucial for sustainable extraction.

Mis-match between Groundwater Extracted and its Recharge

- On one acre of land which is 4000 square meters, rainfall of 750 mm per year implies as under: 750 mm of rainfall is 0.75 meter.
- On 4000 sq. meters, rainfall of 0.75 meter implies = 0.75M X 4000 Sq. M = 3000 cubic meters.
- Given 1 cubic meter is = 1000 litres of water, 3000 cubic meters = 3000000 litres of water.
- Since one gallon of water = 4.54 litres, 3000000 litres of water = 660793 gallons, which is equal to 29 acre inches or ha cms since 1 acre inch or 1 ha cm = 22611 gallons of water.
- Therefore 1 acre with 750 mm of rainfall is approximately equal to 29 acre inches of rainwater assuming modest evapo transpiration.
- Each irrigation of 5 cms for paddy is around 2 acre inches for one acre.

Unsustainable Use of Groundwater

- Considering recharge to groundwater from rainfall of 10%, out of 29-acre inches only 2.9-acre inches will enter the aquifer due to stronger evapotranspiration in this temperate region.
- One irrigation well draws on an average 100-acre inches of groundwater and irrigates maximum 3 acres.
- Thus, for three acres, the total recharge is 2.9-acre inches X 3 acres = 8.7-acre inches or approximately 9-acre inches. Thus, by recharging 9-acre inches of water farmer is pumping out 100-acre inches of water per well on an average every year leaving a gap of approximately 90-acre inches to be recharged by other areas consciously or unconsciously.
- Thus extracting 100-acre inches from a well and recharging only 9- or 10-acre inches is over exploitation leading to massive failure of borewells forcing farmers to invest on drilling new wells continuously.

Two critical issues emerge for the farmer: one is to ensure adequate groundwater recharge and safeguard efficiency of water use for every unit of water. Otherwise, groundwater-based irrigation systems may soon become unsustainable.

Key Measures

Less water, high value crops: As soon as water for irrigation is available, tendency is to shift towards water guzzling crops like paddy, sugarcane, but the cropping pattern should be towards more income generating crop per unit of water that would ensure sustainability. Instead of cultivating paddy/pigeon pea using groundwater, farmers may consider shift to horticulture and floriculture during kharif and small millets during rabi session for economic viability. Micro-irrigation is certainly an optimal solution that ensures efficiency along with good income generation. In the years of its life, it not only pays back the investment but also ensures good income generation with assured sustainability and enough surplus for replacement.

III. Why Proper Upkeep of MI Infrastructure is Essential?

One of the important problems confronted by the usrs of MI is infrequent mechanical issues (especially with pipeline & nozzle blockages) with the system. It is required therefore to set a calendar for periodic maintenance of MI system. Irrigation system maintenance is necessary to ensure most efficient use of water. The best design cannot compensate for inadequate system maintenance. Maintenance actually deals with system installation and regular inspection. Improper installation will cause trouble throughout the life of the system so also neglect of seemingly small issues like reduced water speed or leak in the pipe. A sprinkler system like any other farm equipment needs maintenance to keep it operating at peak efficiency. Parts of the system are subject to wear and tear are the rotating sprinkler heads need lubricant, the pumping set, the couplers and the pipeline. A periodic checking up of the system with a pre-decided time schedule helps to avoid larger failures.

IV. Why to Upgrade to Drip Irrigation?

Micro irrigation systems, also known as drip irrigation or trickle irrigation, have a history that spans several decades. The concept of delivering water directly to the root zones of plants in a controlled manner dates back to ancient civilizations. Following the same principle, modern micro irrigation systems have evolved over time through technological advancements and agricultural research. Sprinkler and drip irrigation systems are both methods of providing water to plants, but they differ in their mechanisms, water distribution, and water use efficiency. The establishment cost of the Drip and Sprinkler irrigation are almost similar and the former has scale efficiency compared to the later. Drip irrigation provides water to the most needed root zone and helps in absorbing the fertilizers if fertigation liquids are used. Sprinkler irrigation provides water through air sprinkler and hence there is a possibility of some amount of evapotranspiration in the air if temperature regime is high.

Water Use Efficiency: Sprinkler systems are generally less water-efficient compared to drip systems due to evapotranspiration in the air and splintering into minute droplets. In sprinkler irrigation more water is required to saturate the root zone than the drip method of irrigation. However, both methods are still more efficient than manual flood watering methods. Drip irrigation is known for its high-water use efficiency. Since water is targeted to the plant's root zone, there's minimal wastage due to evaporation, wind, or surface runoff. This efficiency can result in significant water savings compared to traditional methods.

Today, micro irrigation systems are an integral part of modern agriculture, contributing to sustainable water use, increased food production, and improved crop quality. The history of micro irrigation systems in India reflects the country's efforts to address water scarcity, improve agricultural productivity, and promote sustainable farming practices.

Farmers Need to Note the Following Schemes to take advantage

1: National Horticulture Mission: The launch of the National Horticulture Mission in 2005 further boosted the adoption of micro irrigation systems, especially in horticultural crops. This mission aimed to promote integrated development of horticulture and supported the establishment of micro irrigation infrastructure across the country.

- **Subsidy Programs:** Several states in India introduced subsidy programs to make drip irrigation systems more affordable for farmers. These subsidies covered a portion of the installation costs, making it economically viable for farmers to invest in the technology.
- **Community Participation:** In some areas, community-based drip irrigation systems were established, allowing groups of farmers to collectively manage and benefit from the technology. This approach helped overcome challenges related to land fragmentation and financial constraints.
- **Private Sector Involvement:** The private sector also played a significant role in promoting micro irrigation systems by providing innovative solutions, technology transfer, and after-sales support. This partnership between the government, private sector, and agricultural organizations contributed to the wider adoption of micro irrigation systems.

Table 1: Comparative Water Use Efficiency to be Noted by Farmers

Variable	Drip Irrigation	Sprinkler Irrigation	Flood Irrigation
Water Saving	High 40 - 100 %	High 40 to 80%	Less due to evaporation losses up to 30%
Irrigation Efficiency	80 - 90 per cent	50 to 80%	30 - 50 per cent
Input costs	Less especially in labour, fertilizers, Pesticides and tilling	Higher Fertiliser application cost	Comparatively higher
Weed problem	Almost nil	To some extent	High and reduces yield
Suitable water	Even saline water can be used, but nozzle acid cleaning is necessary	Can be used but Sprinkler hub should be cleaned	Saline water can be used with a risk to solil salinity and salt formation on the crust
Disesases and pest problems	Relatively less	Relatively less	High
Water logging	Nil if Nozzle cleaning is done and pipe blocks attended	Nil if sprinkler hub cleaning is done and pipe blocks attended	About 8.5 mha of area under water-logging problem in India
Water control	High and easy	Good	Less controllability
Evaporation and transportation losses	Very less	Present but less than the flood irrigation	Seepages, leakages etc are very high
Efficiency of fertilizer	Very high and constant supply	Relatively less than drip irrigation	Heavy losses due to leaching
Benefit cost ratio	Excluding water saving 1.3 - 13.3 including water saving 2.8 - 30.0	1.2 to 10.5.	Varies from 1.8 - 3.9
Yield increase	About 20 - 100 more than flood method	About 20 to 60%	Yield is much less compared to drip irrigation

Source: A. Narayana Murthy and R.S. Deshpande 2005.

2: The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is a flagship program launched by the Government of India in 2015 with the aim of improving irrigation efficiency and water management in the agricultural sector. Key features and components of the Pradhan Mantri Krishi Sinchayee Yojana include:

1. **Har Khet Ko Pani (Every Field Gets Water):** This component aims to create sources of assured irrigation through the development of water storage and distribution infrastructure, including building new reservoirs, check dams, farm ponds, and other water harvesting structures. The goal is to ensure water availability for every field, particularly in rainfed areas.
2. **Per Drop More Crop:** This component emphasizes efficient water use through micro irrigation methods such as drip and sprinkler irrigation. It aims to achieve "more crop per drop" by delivering water directly to the root zones of plants, reducing wastage and improving water use efficiency.
3. **Watershed Development:** This component focuses on the holistic development of watersheds to enhance rainwater harvesting and soil moisture conservation. It involves measures to prevent soil erosion, increase groundwater recharge, and promote sustainable land use practices.

4. **Promotion of Precision Farming:** PMKSY encourages the adoption of modern technologies and practices, including precision farming, remote sensing, and GIS (Geographic Information System) for efficient water management and improved agricultural productivity.

5. **Integrated Water Management:** This component aims to create an integrated approach to water management by coordinating with different departments and agencies responsible for water resources, agriculture, and rural development.

6. **Awareness and Capacity Building:** PMKSY includes efforts to raise awareness among farmers about water-efficient practices and technologies. It also focuses on building the capacity of farmers to adopt modern irrigation techniques.

7. **Convergence and Synergy:** PMKSY promotes convergence with other ongoing schemes and initiatives related to water resources and agriculture. This ensures better utilization of resources and a coordinated approach to irrigation development.

8. **Funding:** The program is funded by both the central and state governments. It aims to bring together resources from various sources, including the dedicated budget allocation, the National Bank for Agriculture and Rural Development (NABARD), and other financial institutions.


V. Adoption of Renewable Energies

Majority of farmers rely on electric / diesel pumps for irrigation purposes, apart from rainfall. While the upfront cost of the solar pump is almost 20 times of the diesel pump, operationally they are a more economical solution in the long run. There are also elements of drudgery that associated with diesel pumps. Electric pumps, while affordable, depend on infrastructure available in the region, but are unreliable.

Solar water pumps are becoming increasingly popular irrigation system over diesel and other conventional pumps. These pumps get powered by solar panels and save from buying fuel and electricity costs for operation. They help in significant reduction of Green House Gases emissions, and low environmental impact when compared to their counterparts. Installation of solar pumps is highly beneficial as they can pump water judiciously in relatively sunny locations unlike HP diesel pumps which irrigate in a limited time period but empty the reservoirs a lot faster.

The solar irrigation systems were implemented through three models, via Individual farmers, Water User Groups and Service Entrepreneurs. These farmers stated multiple benefits they observed post installation of solar water pumps for irrigation. Enabling access to renewable energy for irrigation has resulted in reduction in issues faced like drudgery and high costs associated with irrigation. Farmers mentioned that improvement in area under irrigation was seen, there was an increase in both cropping intensity and cropping diversity and it positively affected their crop produce which was sold in various markets.

Key Message: Benefits of Renewable Energy

1. Increase in land under Irrigation with less cost in long run
2. Reduction in issues faced with Irrigation.
3. Reduced reliance on non-renewable energy sources for irrigation.
4. Reduced drudgery in irrigation
5. Increase in cropping intensity
6. Increase in cropping diversity
7. Increase in produce sold in markets
8. Increased net income flow

Other Potential Water Conservation Measures

Water conservation methods like drip irrigation and mulching must be promoted along with the provision of Solar Irrigation Systems. Such a combination can provide sustainable solution for depleting groundwater resources and increasing need for energy for irrigation. Along with drip irrigation, the process of fertigation may also be adopted. Relevant Government scheme linkages must be identified for adoption of drip irrigation systems. For example, under the **National Mission on Micro Irrigation (NMMI).** 50 per cent subsidy is given to farmers, with the Central government bearing 40 per cent of the cost and the state government bearing 10 per cent. Combining with mulching further improves the efficiency in water management as well as controls weeds. Mulching has also seen significant saving of labour.

5. Potential for Convergence:

Irrigation in the country predominantly depends on groundwater pumped through 19 million electrical, and above 9 million diesel pumps. Despite such high number of pump sets, 53 percent of the net sown area in the country remains unirrigated. Against such a backdrop, **solar pumps** are emerging as an alternative to conventional pumps, filling in gaps of unreliable supply to electric pumps, and high fuel costs in running diesel pumps. Solar-powered irrigation systems hold the potential to enhance irrigation access, advance low-carbon agriculture, reduce the burden of electricity subsidies on the government, and improve the resilience of cultivators against a changing climate.

Kisan Urja Suraksha Evam Utthaan Mahaabhiyan

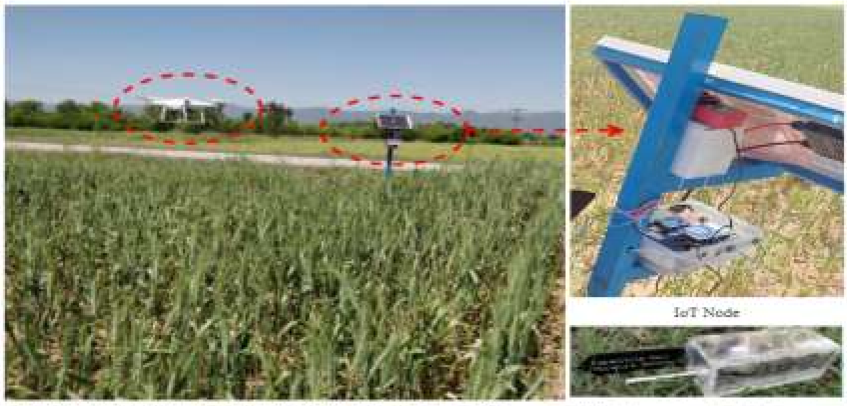
In December 2017, the central government announced a new scheme called KUSUM (Kisan Urja Suraksha Evam Utthaan Mahaabhiyan), with a target of installing 17.5 Lakh stand-alone pumps, and solarisation of 10 lakh grid-connected pumps by 2021-22. The number of installed pumps in India at the time was about 1,48,000. In order to scale up the adoption of solar-powered irrigation systems, it is essential to ensure their economic viability, environmental benignity, and social acceptability.

VI Precision Agriculture

First appeared in 1970s in the United States, Precision farming is defined as information and technology based agricultural management system to identify, analyze and manage site soil, spatial and temporal variability within fields for optimum profitability, sustainability and protection of the environment. . Precision agriculture can effectively save input, reduce cost and abate the after effects to environment. The object to be controlled in precision farming is the soil and plant. Precision agriculture is the application of technologies and principles to manage all aspects of agricultural production for improving production and environmental quality. Precision agriculture is not a single technology, but rather a set of many components from which growers can select to form a system that meets their unique needs and operation size. These components help us to meet the demands of precision agriculture practice i.e. application of Right Input, in Right Quantity, at Right Place, at Right Time and by Right Method. However, the cost of cultivation increases due to initial capital cost as well as the recurring cost but the net benefit flow increases and the cash flow matches in the first few years thereafter providing sizeable increased income.

The biggest benefit of precision farming is that it gives producers the ability to manage their farm on a production zone basis rather than a whole field basis. This shift allows farmers to save time and money and helps them offset the rising cost of chemicals, nutrients, fuel and fertilizer.

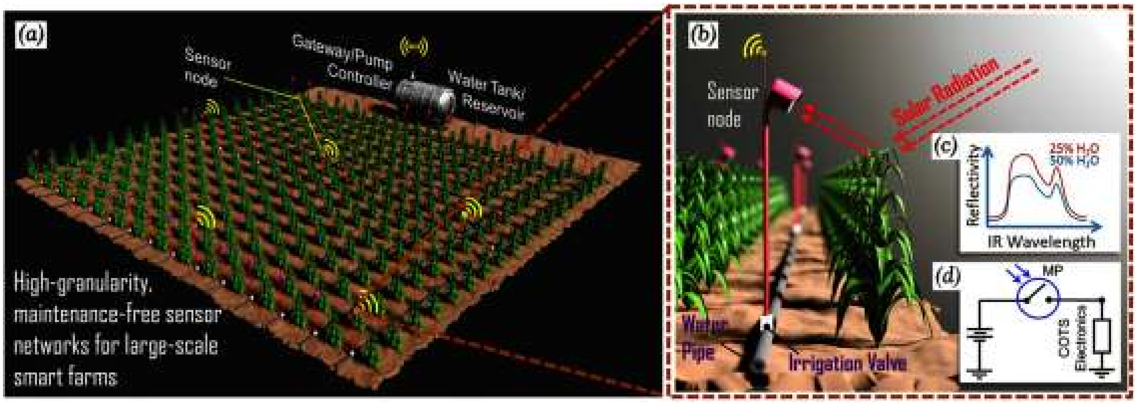
Although India has made considerable advance in agricultural research, but still the blanket recommendations of fertilizers for adoption over larger areas are in vogue. These blanket recommendations are no more useful to enhance productivity gains, which were witnessed between 1960's and 1980's. Now, to enhance growth rate in productivity, precision agriculture technology has to be developed. Precision agriculture is important because of the following points: i. nutrient variability within a field can be very high affecting optimum fertilizer rates ii. yield potential and grain protein can also vary greatly even within one field, affecting fertilizer requirement iii. increasing fertilizer use efficiency will become more important with increasing fertilizer costs and environment concerns iv. irrigation at critical stages is very important and v. best and stress management at the early stages of the crop helps the farmer to get maximum yield



Drone taking flight along with IoT node deployed across the wheat Field

IoT Node

Soil Moisture sensor & Soil Temperature Sensor



(**a**) Schematic illustration of precision farming. Source: Risso, A., et al. .

Way Forward

1. Farmers can adopt either drip or sprinkler iriigation through the ongoing schemes of teh Government and that can save their water resources from 30 to 80 percent, if proper care is taken. Thus they can achieve more income per drop of water.
2. The initial cost of both drip and sprinkler irrigation are high and not affordable to small or marginal farmers hence the State and teh Central government have initiated schemes for subsidising the initial capital cost of establishment.
3. The recurring cost in both teh methods is far below the traditional flood method of irrigation. The saving is on weeding, fertilisr application, irrigation channels maintenance and wastage of water.

4. Farmers must keep a continuous vigil on the pipe lines and drip nozzles in drip irrigation but in sprinkler method care should be taken of sprinkler hubs, Impact arm, Spreader Nozzle, Trajectory bar and Oiling the bearings.
5. Solar energy pumsets should be encouraged and that will save energy cost . bsides farmer may take advice of using gravity method by giving proper gradients to teh filed soil.
6. A maintenance calendar be placed to examine all teh operations personally every month even when the sets are not in use.
7. As far as possible farmers must decide against water guzzling crops that provide low income per unit of efforts and money.

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About the Organisations

About ISEC

The Institute for Social and Economic Change (ISEC) was established in 1972 by the visionary, scholar, statesman and a distinguished social scientist Prof. V K R V Rao. It has always been conceived as an all-India institute of interdisciplinary research and training in social sciences. The principal objective of the Institute is conducting research, pure and applied, in social sciences and enlarging the canvas to include Doctoral programme, training and policy dissemination. www.isec.ac.in

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The Hanns Seidel Foundation, founded in 1967, is a German political foundation, working "in the Service of Democracy, Peace and Development". It has been active for more than 40 years in the field of political development cooperation and is currently taking an active part in 80 projects in 60 countries worldwide. In India, the Foundation started its work in the year 1996 and undertakes projects to support India's federal democratic structure, strengthen geopolitical relations, water governance, and improved access to justice. The projects are implemented with government and non-government partners at regional, national, and state level, aiming at increased systemic efficiency. The Foundation seeks to contribute to India's sustainable development by strengthening peace, democracy, and rule of law. More information on the work of Hanns Seidel Foundation India can be found at https://india.hss.de/.

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