THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES

Groundwater Depletion and Negligence of Water Sustainable Technologies: A Challenge towards Sustainable Agriculture Development of Gujarat

Ashok Kumar Maurya
Research Scholar, Department of Economics and Planning, School of Social Sciences, Central University of Gujarat, Gandhinagar, Gujarat, India

Abstract:
The issue of sustainable development is very debatable in modern era of development. A lot of discussion is going on regarding with sustainability at the theoretical level but it is very difficult to achieve practically. Government of Gujarat has tried to implement various water conservation methods but still in form water sustainable techniques in form of drip and sprinkler irrigation the picture is not satisfactory. This paper has tried to analyze the status of micro irrigation system and the reasons of failure of water saving technologies in Gujarat specially in agriculture dominated area. Limited availability of surface water and its poor distributions status is a big bar in the progress of agriculture and hence groundwater plays an important role in the development of agriculture.

Keywords: *Agriculture, Irrigation, Groundwater extraction, Over-exploitation, Depletion, water sustainable techniques, Drip irrigation, Sprinkler irrigation, Water Sustainability, Sustainable development*

1. Introduction

Conservative use of groundwater and sustainable development both are important for the balanced ecology system. The indicators of the sustainable development run the composition of the various environmental and ecological variables and water is a very important component of the environmental issue. Conservative use of water for drinking purpose and agriculture both are the pillars of the sustainable development. Innovative irrigation technology is generally as raising water use efficiency along with multiple benefits (Levidow *et.al*, 2014). In developing countries, environmental degradation has become a burning issue. For the rapid economic development developing nation like India overexploit their natural resources unevenly. Rapid growth of population, urbanization and for better agriculture productivity, groundwater resources has become a better and available option for the fulfillment of all demand related to water. The increasing demand of food items is making stress on irrigation water in those countries which are already experiencing water scarcity and in which agriculture is a large consumer of freshwater in form of groundwater (World Water Assessment Programme, 2009). In worldwide, near about 40 percent of global food production depends on irrigated agriculture and 70 percent of the groundwater withdrawal is used for the irrigation in agriculture. In India, more than 20 million private wells are running for the irrigation purpose (Dutta, 2008). Farmers adopt groundwater based irrigation mechanism due to universal availability of groundwater, sufficient quantity of storage and easily accessible of well drilling technologies. According to WWAP (2009), till 2009, 47 percent world population will fall under the water stress regions and against this backward irrigation technologies and practices that increase the agriculture productivity of water are critical.

The most of the agriculture rich areas are over exploited especially Punjab, Haryana, Rajasthan and Gujarat. In Gujarat, there is decline of the level groundwater table one meter per year in 1970 to 2 to 8 meter per year in 1997 (Dutta, 2008). This depletion has created a huge economic and environment loss on groundwater depleted region of Gujarat. As the groundwater level decreases, the cost of pumping increases, raising the average cost of irrigation for farmers using pumped groundwater. Farmers may respond to the rising irrigation cost of water by altering the quantity of water of changing the cropping pattern (Blanke*et. al*.2006). The main overexploited region of the Gujarat is the northern part of the State. The share of irrigated land is 85 percent in all over agriculture land and major part of the land is irrigated by the groundwater resources. Groundwater resources have covered 19 percent area of all over irrigated area and North Gujarat covers a large part of it (Maurya and Dutta, 2015). No doubt, the state of Gujarat is running a huge number of surface water schemes in form of minor, medium and major irrigation projects. Recently, State government has implemented many dam projects and increased canal system on agriculture rich area. But still some fundamental problems have been noticed for the smooth run for these projects. Surface water scarcity is one of them. In canal loaded area, farmers are not able to get water in round the year rather than it is compulsory to farmers for alternative option, which should be based on groundwater resources. The cumulative impact of pumping decision, problem of groundwater depletion, impact on hydrological, social, economic and cultural all have created problems on local level as well as regional level. Depletion of water resources and increasing population growth both

have impacted the declining irrigated land per capita and now irrigated lands produce 40 percent of total food supply (Hargreaves and Mekley, 1998). The main impact of groundwater depletion falls under the two areas, one is agriculture productivity and the other is environmental issues. Changing in cropping patterns, irrigation cost, land degradation, less agriculture and water productivity are some important emerging issues in agriculture. Increasing irrigation with respect to increasing groundwater depletion is main problem in agriculture production and has faced a big challenge towards sustainable groundwater management. Excess quantity of groundwater recharge and less use of groundwater both are effective and fruitful methods to maintain groundwater balance at appropriate level. Khanna *et.al* (2002) has examined that how water demand is affected by the three drivers with change in cropping pattern, intensive margin changes and technology changing effects. Water sustainability technology for irrigation is an effective method for sustainable groundwater management. In rain fed and groundwater depleted area, drip and sprinkler irrigation systems are effective tools of irrigation (Ibragimov *et al*., 2007). In water scare region, it seems that drip irrigation has great potential in saving large quantity of water in irrigation, and will increase more area under this irrigation system resulting in large increasing in productivity (Aujla *et al.*, 2005). A low quantity of water goes directly to the root area of a crop in an accurate and economical manner that increases efficiency of irrigation of crops in areas in boosting and stabilizing crop production with increasing the amount and stability of the food supply (Burney *et al.,* 2010). Despite academic and practitioner recognition of the advantages of drip and sprinkler irrigation and extensive promotion over the past two decades, global adoption remains below 4 percent of total irrigated land area (International Commission on Irrigation and Drainage (ICID), 2012).

1.1. Objective of the Study

This paper basically aims at exploring the worldwide technological challenges of drip and sprinkler irrigation system in agriculture through existing related literatures. It will explore and analyze the technological challenges of drip and sprinkler irrigation system for creating obstacles in agriculture of Gujarat region of India. After achieving both objectives, a comparative analysis will run and identifies the different nature and problem of technological challenges in Gujarat. For data sources, one agriculture rich district Mehsana has been chosen for the data collection.

2. Data and Methodology

The concept of water saving technologies is very broader. The research has been done in various aspects of water saving technologies. Here with two types of technology have been taken drip and sprinkler irrigation systems for the exploring and data analysis for elucidating actual condition of this technology in study area. This study is based on primary survey as per 10 percent (60) villages of Mehsana district of Gujarat. The distribution of the area covers all types of land structure (fertile and unfertile), irrigation facilities (groundwater and surface water), and area (safe and over-exploited). Each village has at least selected one respondent for the survey. This part of the State is rich for their agriculture activities as well as animal husbandry and horticulture. This part of the state is not new for their richness of agriculture but rich for last four decades. This is the part of northern part of Gujarat of West India and geographical location is 72”07’ 0 to 72”26’ 0 East Longitude 23”.15’ 0 to 23”53’ 0 North Latitude. The method of data collection is based on interview method and overall villages. With the help of interview methods, the advantages and disadvantages of drip and sprinkler irrigation on farm level have been explored. The interview was conducted in January to March 2015 in Vijapur, Mehsana, Kadi and Visnagar Taluka of the district. The main respondents for the interviewing are head of the villages, agriculture managers as well as marginal and large farm owners. There is no guarantee that every village has got this technology but those villages that have no such type of facilities also tried to understand the possibility of not having. The nature of data collection is cross sectional data type. The survey is divided in two types of problems. Those farmers who have this irrigation system and have explored the problem and secondly those who do not have such type of facilities and have tried to find out the egress of this system. The analysis of the paper is based on qualitative data sources of primary survey and identification of problem and area is based on latest minor irrigation census 2006-07. This irrigation census has shown shocking results in terms of minor irrigation technology and has given inverse relationship between groundwater exploitation and switching towards drip and sprinkler irrigation systems.

2.1. Theoretical and Empirical Review of Water Sustainable Technologies

A scientific evolution compared the irrigation efficiency of various irrigation systems in California found that micro irrigation systems are seen as efficient technology but performing less compared to traditional surface irrigation methods such as furrow and boarders (Hanson *et al*., 1995). Theoretical prospective began with technology transfer approach (Garb & Friedlander, 2014) of water saving in irrigation. The systematic nature of technology has emerged as a key them in the history and sociology of technology in 1960s. The early literature shaves very complicated and nature of understanding was not easy to explore the thing we usually point to. These outlooks emerged as a part of key challenges to earlier basic understandings of the technological development. Garb & Friedlander (2014) have explored the fundamental technical problems of drip irrigation in Israeli irrigation innovation systems. Most of the drip irrigation has settlements on marginal lands. Farms are communal and no individual ownership. Lands leased from government rotation of roles including agricultural practitioner among kibbutz members. In African context, there are some key reasons of failure of technologies where water supply problem which leads to discontinuing maintenance problems and eventual abandonment. But this breakdown appears differently to the stakeholders, where each see it from their own perspective.

Farmers have reported problems of the maintenance of their irrigation systems followed by water supply and marketing related problems. Kulecho and Weatherhead (2006) have focused on the market of limited size of water saving technologies and it does create the obstacles in growth of industries and uptake of smallholders of drip irrigation industry. On the other hand, the manufacturers and suppliers of drip irrigation have made clear that advanced drip irrigation system needs to be connected with advanced water supply

system. The tragedy is that farmers have failed to make perfect composition of the drip irrigation technology and sometime they find it useless. The main reason of technology failure in future may be inadequate knowledge and vagueness of output of drip irrigation technology. Wolteringet.al (2011) describes four models of African Market Garden (AMG), a holistic horticultural production system for small producers. The design of the system is similar to like other low pressures systems. This system was basically designed for those farmers who have 2-3 hectares' land because the technological features is appropriate for the medium and large farmers and very expensive, marginal farmers cannot afford this technology. African Market Garden (AMG) technology failed massively after some time and main reason was that due to poor equipment maintenance, and violence of the user manual of drip irrigation technologies. According to the Garb & Friedlander (2014), agriculture development in Sub Sahara Africa presents unique and difficult challenges for the promotion of new technologies; weak institutions, uneven distribution of infrastructure is unevenly distributed and often poor quality. Farmers frequently lack access to markets and basic economic assurance. Advanced irrigation technology cannot be promoted as poverty alleviation and food security enhancement tools. In this context by a "technology transfer" approach that relocates hardware, while ignoring the local circumstances that are so different from the ones in which the hardware evolved and operate in such as exemplary way. Kampas, Petsakos and Rozakis (2012) evaluated Water Framework Directive (WFD) and Common Agriculture Policy (CAP) of European countries. Under CAP reform it appears decoupling favors the introduction of drip irrigation for low and medium water prices. But increasing water prices more than 0.12 €/m3 the share of drip irrigation decline and under high water prices (0.20 €/m3) drip irrigation technology disappear under the CAP reform. At a crop level there are some important variations. Water pricing is more expensive in fully decoupled maize compared to the partially decoupled cotton in term of adopting water saving technologies.

Water price increases have induced farmer to force to induce farmers to adopt technology and appropriate practices for conserving water (Caswell and Ziberman, 1985). To gain additional benefit of such technology, most compulsory to friendly and proper system design, alongside proper installation, operation and maintenance, despite of the irrigation method used (Hanson *et al.*, 1995). Howell (2003) and Irmak*et.al* (2011) have compared the different irrigation methods and have found that potential of micro irrigation systems and have more variation and varying from 0.7 to 0.95. Levidow *et. al.* (2014) has focused some fundamental problem of drip and sprinkler irrigation system after installation of systems when individual farmers have made significant investment in irrigation technologies, but their implementation has not been systematically evaluated for effectiveness to better knowledge about crops and yield response to different irrigation management strategies, etc. Due to these reasons, farmers pay higher water prices yet do not obtain the full potential benefits through water efficient practices. Aujla *et al*. (2005) has focused mainly on the drawbacks of drip irrigation system in terms of high initial investment. Its cost can be recovered in short period if proper nutrient, water management and design principals are followed. Singh (1978) studies the effect of proper planting configuration on water use and economics of drip irrigation system for various horticulture crops and has found that proper paired row planting reduced the cost and water use by 50 percent. Blanke*et.al*, 2007has highlighted the small size of plots and fragmented nature of most farm holdings in northern China operating a sprinkler irrigation system requires coordination for use. It is difficult to use a sprinkler that irrigation in a large circular pattern on one plot without irrigating the plots of other households around it. Zuo *et.al* (2013) also notes that sprinkler and drip systems save labor in addition to water, but have relatively high costs, which might limit the use of sprinkler technology to vegetable and fruit production. Blanke *et.al*, 2007 finds a negative relationship between the level of adoption of most water saving technologies and the use of surface water and also finds from empirical result that most of the sprinkler irrigation systems runs at the water level 0-10 meter and no one at the water level 30-150 meter in North China.

2.2. Minor Irrigation Development: A Macro Level Context

Minor irrigation development is fruitful for environment as well as provides rural employment and economical for agriculture activities. It means minor irrigation development utilizes maximum benefit of groundwater resource with less exploitation of it. According to Census 2011, India's population has been crossed above the 120 crore and fulfillment of the necessity of food is a big issue. So, it is compulsory to increase the food production without imbalance of natural resources. According to the Planning Commission working Group on Minor irrigation (2001), they felt with respect of investment on minor irrigation project, this sector remains neglected sector due lack of accountability among States and Central government, lack of coordination, mismanagement and insignificant sector of government priorities.

State	Total Sprinkler Irrigated Area (in Hectare)	State	Total Drip Irrigated Area (in Hectare)	State	% share of total Irrigated area of Drip and Sprinkler irrigation system
Rajasthan	1606675	Karnataka	69520	Rajasthan	72.31
Madhya Pradesh	240441	Maharashtra	48905	Madhya Pradesh	11.50
Karnataka	39970	Andhra Pradesh	23929	Karnataka	4.88
Uttar Pradesh	37316	Madhya Pradesh	17575	Maharashtra	3.56
Maharashtra	31023	Rajasthan	14392	Uttar Pradesh	1.91
Gujarat	30040	Tamil Nadu	12890	Andhra Pradesh	1.44
Chhattisgarh	22044	Uttar Pradesh	5689	Gujarat	1.43
West Bengal	12787	Bihar	5652	Chhattisgarh	1.04
Andhra Pradesh	8503	Gujarat	2092	Tamil Nadu	0.62
Kerala	2933	Chhattisgarh	1297	West Bengal	0.58
Assam	1559	Kerala	1135	Bihar	0.31
Bihar	1419	Punjab	474	Kerala	0.18
Tamil Nadu	1155	West Bengal	249	Assam	0.07
Goa	939	Odisha	196	Goa	0.04
Punjab	224	Uttarakhand	99	Punjab	0.03
Odisha	127	Assam	82	Odisha	0.01
Himachal Pradesh	122	Jharkhand	82	Himachal Pradesh	0.006
Jharkhand	37	Goa	46	Jharkhand	0.005
Jammu & Kashmir	12	Jammu & Kashmir	45	Uttarakhand	0.004
Haryana	0	Himachal Pradesh	16	Jammu & Kashmir	0.002
Uttarakhand	0	Haryana	0	Haryana	0

Table 1: State- wise total Irrigated area through Drip and Sprinkler irrigation system
Source: - Minor Irrigation Census (2006-07)

In Indian context there is huge equality among the states. Some States like Rajasthan, Madhya Pradesh, Karnataka and Maharashtra have given satisfactory performance in terms of water saving technology. If we try to make comparison between agriculture dominated area and water saving technology the shocking results appeared inversely between them. The development of such type of technology failed to provide appropriate facilities in agriculture rich area. On the other hand, Punjab, Haryana, Gujarat and little bit Uttar Pradesh all has given worst performance in terms of water saving technologies. Rajasthan is carrying a huge percent share of land with drip and sprinkler irrigation prone area. Although with carrying huge share of land area the problem of groundwater depletion has also increased and groundwater level has failed drastically. There is no question to say about groundwater depletion to other states where agriculture land area and productivity both are more. Punjab, Haryana and Gujarat states are also facing great difficulties due to depletion. Government schemes and policies have been failed to provide alternative water saving irrigation option in India. Since Independence State and Central Government both have always focused on large, medium and small dam projects and has continuously tried to increase canal irrigation command area. So this is the other reason of demolishing the water saving technologies.

2.3. The Development of Water Saving Technologies (Drip and Sprinkle) in Gujarat

The characteristics of districts of Gujarat are showing regarding minor irrigation in the same pathway like other states of India. Banaskantha district is carrying more than 85 percent of total area of land of whole state under drip and sprinkler irrigation system. Surendranagar got first position in drip irrigation with Banaskantha in sprinkler irrigation systems. Mehsana and Patan had no land for such type o irrigation system till Minor Irrigation Census 2006-07. In North Gujarat Mehsana falls under the most over exploited area and groundwater depletion is a major obstacle in agriculture and allied services. The significant development of water saving technologies is near about zero in this area and has failed to make proper implementation. If we make a comparison between Gujarat and India in terms distribution of drip and sprinkler irrigation technologies, then table 1 and table 2 both show same picture and nature of distribution. It is questionable issue that how is it distributed unevenly? If we see state level, then what is the reason is that the development of drip and sprinkler irrigation is much more in Rajasthan and same picture is again showing in Banaskantha in Gujarat State. The main reason of failure of such technologies is the uneven development of minor irrigation systems.

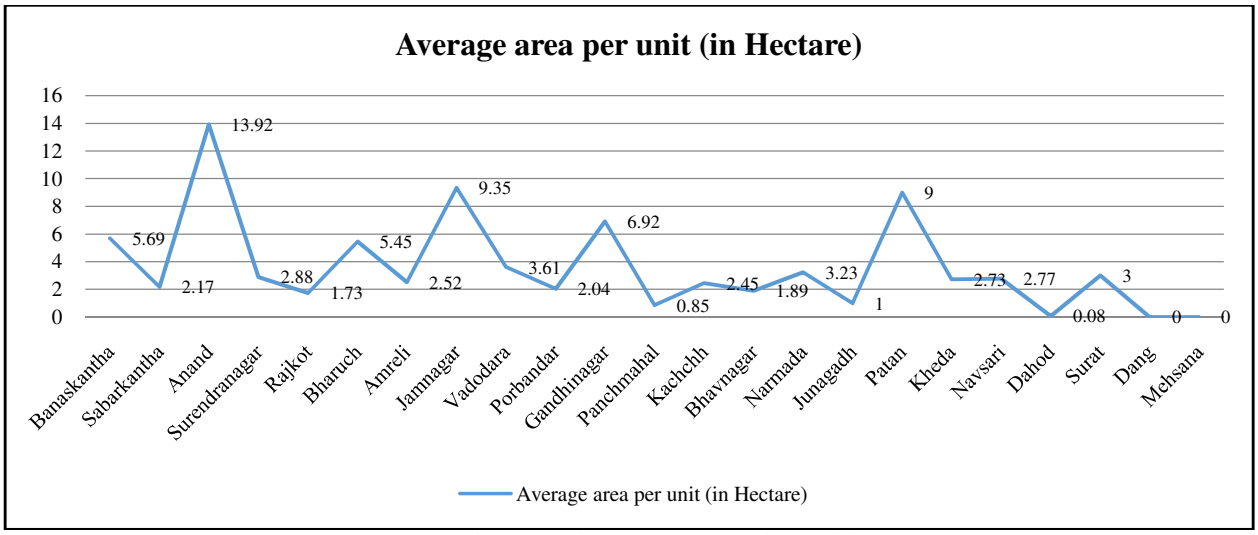

Figure 1: Total Irrigated area of Drip and Sprinkler system
Source: - Minor Irrigation Census (2006-07)

Banaskantha is carrying 5.69-hectare land per unit of irrigation system (drip and sprinkler). If we see the average land of unit farmer, then it has been found that maximum farmers who belong to big farm land fall under this category. This irrigation technology is away from small farm holders. The literature review explains the detail reasons of obstacle for small farmers like lack of awareness and knowledge, financial assistance, inappropriate water supply etc. Adoption of this technology is not an easy job for small and marginal farmers as well as large farmers also in various prospective.

2.4. Challenges of Water Saving Technologies (drip and sprinkler)

The survey of the sample villages is showing maximum different causes and results of challenges of these technologies. The analysis is based on two aspects, environmental and economic. Theses dimensions show the actual and grassroots issues of failed adoptive strategies of technological development.

2.5. Environmental Aspects

The main vision of any such type of technology is necessary for the fulfillment all required inputs for running on ground level. The availability of water at a constant rate in long time is necessary for the success of the technology. In study area, there are two types of agriculture land, safe as well as over-exploited. In both types of land agriculture is major contributor. The environmental condition with respect to water for irrigation is found quite in varying different areas. From safe area, there is not much more problem of groundwater depletion but also shows improvement in groundwater level and canal irrigation command area also increased drastically. Farmers are getting water for their crops timely through canal irrigation and they have more curiosity about to use drip and sprinkler irrigation systems. On the other side increasing groundwater level has also pushed back to farmers to invest and use of these technologies. Because of the cost of installation and after it maintenance cost is a big deal of expenditure for their continuity. Since last decade, a lots of minor and major irrigation projects have been completed and some work is in progress in northern part of Gujarat. For construction of check dams in this area, Gujarat government has given an appropriate amount of budget allocation allocated for on it.

On individual level, irrigation cost plays major role for the adaptation of new more efficient technology. Groundwater development is another important factor for irrigation. In safe area performance of groundwater development stands at satisfactory level and it is shining positively in terms of ideal level of groundwater level. The irrigation cost is much less compared to overexploited areas of agriculture. Since last decade, increasing water level or constant groundwater level shows the disinterest of using this type of technologies. At this time Dharoi Dam project and Sujlam Suflaam Project both are covering a large part of water scare regions of North Gujarat (agriculture rich prone area). The alternative option of groundwater is easily available for the farmers of a marginal cost, so that farmers are not interested to adopt expensive irrigation technologies.

Those villages that fall under the over-exploited parts sample area, the problems are totally different. Groundwater depletion has emerged as a huge curse of agriculture and allied services on this area. Lack of surface water schemes in this area seems to more difficulties to run such type of irrigation technologies. Higher irrigation cost with less amount of discharge rate of tube wells has created double standard problems for the farmers. Farmers are totally trapped due to high irrigation cost and dryness of tube wells. A large part of the agriculture income of farmers goes in to the water cost, maintenance cost and investment of new tube wells. In survey, it was found that not a single farmer is in position to install the drip and sprinkler irrigation system on their agriculture land by paying extra cost on irrigation. For the water saving right now it is necessary to spread more money firstly for pulling water from ground and secondly it is easy to invest money for proper redistribution of water on agriculture land through drip and sprinkler irrigation system. So this is the main drawback to push back these technologies in that area. To make them the owner of individual tube wells is too difficult job for small and marginal farmers. Investment for drilling new tube wells, their maintenance cost and

irrigation cost all three are difficult task for small and marginal farmers. Private cooperative systems are best solution for the reducing irrigation cost and investment. A group of farmers construct a common tube wells and distribute their expense according to their share of land that comes under that particular tube well.

Area	Per Tube well land (in acre)	Per Tube well farmer (partnership)
Over-exploited Area	15	13
Safe Area	15.62	7

Table 2: Status of Average farmer shareholders per tube well
Source: - Based on Primary Survey

It has been noticed that the tube well number of partner farmers are near two fold in over-exploited area compared to safe area and in both cases the total land area comes same near about 15 acres. Drip and Sprinkler irrigation systems want less water but continues much more time compared to furrow irrigation. But restricted electricity supply (8 hours per day for agriculture purpose) is not enough to fulfill the requirement of water for irrigation to all farmers. In overexploited area with less discharge rate, the hour of pumping per acre has increased significantly and demand of water exceeds to supply of water, the consuming water saving technologies fails due to inappropriate time management of irrigation water and lack of water supply.

Year	Dry Tube wells (in percent)
Before 2000	18.92
2001 to 2005	25
2006 to 2010	27.7
2011 to till now	28.38

Table 3: Year wise no. of dry Tube wells
Source: - Based on Primary Survey

The over-exploited areas of Mehsana district have suffered due to dried up tube wells in particularly over- exploited areas. The failure and unsuccessful of drip and sprinkler irrigation systems is one of them. During survey, some farmers have highlighted the reason of failure of their drip and sprinkler irrigation system. It is because of dryness of their tube wells but now they are dependent to neighbor's tube well or installed new tube well so far from pervious tube well. Uncertainty of water supply is one of the major problems to encourage such type of effective technologies and create obstacles those who have already installed. Switching from own tube well to others tube well and shifting the place of tube well due to dryness are major problems of agriculture prone area especially in over-exploited villages.

Government is running a lots of minor irrigation projects particularly for surface water development. But expected outcomes are not at a satisfactory level. Because of surface water supply is limited and some area face geographical disadvantages. For drip and sprinkler irrigation a sufficient quantity of water is necessary to run.Due to lack of surface water it is too difficult and in monsoon season it is not possible to irrigate agriculture land through surface water schemes excluding canals. Canal catchment areas also suffer due irregular water supply and scheduled water after 15 days for next three days. This schedule does not remain fix for whole year. Limited surface water supply also cannot contribute to pull upward this type of irrigation technology.

2.6. Economic Aspects

Economic tools are another key drivers of technological switch over from traditional to modern irrigation technology. If any new technology introduces in any field, then it is very important to introduce a proper investment and make positive atmosphere. Mehsana is carrying a large number of small farmers especially in over-exploited area. Due to huge investment for setup new a tube well and increasing rate of dry tube wells and excess maintenance cost impose negative impact on their economic statues. Farmers have failed to purchases new land and less productivity also makes them weak in terms of their economic condition. Small size of land is not friendly with drip and sprinkler irrigation systems and run successfully on large part of land. Small and marginal farmers have less capital and cannot invest in any expensive irrigation technology. A large part of their investment goes to the drilling new tube wells and with their high maintenance cost. A large chunk of their investment goes to drilling new tube wells so they could not afford to other upgraded irrigation technology related expenses.

2.7. Government Failures to reach Advanced Irrigation Schemes to Individual Farm Level

Lack of knowledge is curse for any upgraded version of technology. From ancient time furrow and border irrigation system has become very popular and farmer friendly. But, when government introduced new advanced irrigation system for switching traditional technology to advanced technology, it was necessary to spread full knowledge and provide technical training to farmers and, give details about profits of upgraded technologies on enhancing economic condition of farmers and on environment related issues.But government could not educate the farmers about such type of technologies and also fail to advertise the advantages of it. The mismanagement of government fund and poor marketing both have brought fuel to fire. The government provides subsidy for setup new drip and sprinkler irrigation system but government process is too difficult. After subsidy, cost of new setup has become costlier. The ratio of the failure of irrigation setup after one or more than one is quite noticing. After installation, lack of knowledge, indolent

services and lack of technical knowledge of owner all add failure in this advanced technology of water saving. Government has made compulsory to install to each farmer when they go to drill new tube well. Some farmers have shown interest to setup but the situation of over exploited area whereas the other farmers are showing interest in installation. This practice is not possible in partnership of tube wells because all partners cannot show interest at the same time. For reducing groundwater depletion and management of groundwater on farm level, government has restricted to supply electricity for agriculture purpose. At present, agriculture sector is getting eight-hour electricity per day. The electricity restricted policy is also creating the problem of farmers towards attracting advanced irrigation technologies.

2.8. Conclusion

Agriculture sustainability is a million-dollar question in the State of Gujarat. The reason is that Gujarat is suffering in terms of surface water as well as groundwater. No doubt the Government of Gujarat is trying its level best to solve this problem at the earlier with the help of water sustainable technology but for the small and marginal farmers it is a distant dream. Economically they are weak and their landholding sizes are pretty small. Through Government of Gujarat is providing subsidy to the marginal and small farmers still for them it is not a cakewalk. If we want to cherish the dream of agriculture sustainability in Gujarat, the people and the civil society all have to work together to help especially small and marginal farmers in terms of irrigation as drip and sprinkler irrigation. No doubt Government has tried its level best to reduce groundwater depletion and its management at farm level. Side by side for agriculture, government has tried supply sufficient power supply but that is not enough. The need of day is that farmers at all levels should be made focused regarding water saving technologies. So agriculture sustainability in prosperous Gujarat is a distant dream.

3. References

i. Dutta, P.S . (2008). Groundwater Ethics for its Sustainability, Groundwater Management: Sustainable Approaches, In Meenu Bhatnagar (Eds), The Icfai University Press, pp. 83-96
ii. Garb, Yaakov and Friendlander, Lonia. (2014). From transfer to translation: Using systemic understandings of technology to understand drip irrigation uptake, Agricultural Systems, 128. 13-24
iii. Kampas, Athanasios, Petsakos, Athanasios and Rozakis, stelios . (2012). Price induced irrigation water saving: Unraveling conflicts and synergies between European agricultural and water policies for a Greek Water District Agriculture Systems,113. 28-38
iv. Aujla, M.S, Thind, H.S and Buttar, G.S. (2005). Cotton yield and water use efficiency at various levels of water and N through drip irrigation under two methods of planting. Agriculture Water Management,71. 167-179
v. Blanke Amelia, Rozelle Scott, Lohmar Bryan, Wang Jinxia and Huang Jikun. (2007). "Water saving technology and saving water in China. Agriculture Water Management , 87. 139-150
vi. Zou Xiaoxia, Yu'eLi, Cremades, Rogar, Gao Qingzhu, WanYunfan and Qin Xiaobo. (2013). Cost-effectiveness analysis of water-saving irrigation technologies based on climate change response: A case study of China. Agriculture Water Management. 129. 9-20
vii. Ibragimov, N., Evett, S.R., Esanbekov, Y., Kamilov, B.S., Mirzaev, L., Lamers, J.P. (2007).Water use efficiency of irrigated cotton in Uzbekistan under drip and furrow irrigation. Agriculture Water Management. 90. 112–120.
viii. Burney, J.A., Naylor, R.L. (2012), "Smallholder irrigation as a poverty alleviation tool in sub-Saharan Africa", World Dev. 40, 110–123
ix. Hanson, B., Bowers, W., Davidoff, B.1(995). Field performance of micro irrigation systems. In: Micro irrigation for a Changing World. Proceedings of Fifth International Micro irrigation Congress, April 2–6, 1995. American Society of Agricultural Engineers, Orlando, FL. 769–774.
x. Kulecho, I., Weatherhead, E. (2006). Adoption and experience of low-cost drip irrigation in Kenya. Irrig. Drain. 55. 435–444.
xi. Woltering, L., Pasternak, D., Ndjeunga, J. (2011). The African market garden: the development of a low-pressure drip irrigation system for smallholders in the Sudano Sahel". Irrig. Drain. 60, 613–621.
xii. Howell, T.A., Eisenhauer, D.E.(1997). Irrigation performance measures: efficiency and uniformity. J. Irrig. Drain. Eng. 123. 423–442.
xiii. Irmak, S., Odhiambo, L.O., Kranz, W.L., Eisenhauer, D.E. (2011). Irrigation Efficiency and Uniformity, and Crop Water Use Efficiency. Lincoln, NB: University of Nebraska–Lincoln Extension, http://extension.unl.edu/publications
xiv. Levidow Les, Zaccaria Daniele, Maia Rodrigo, Vivas Eduardo, Todorovic Mladen, Scardigno Alessandra. (2014). Improving water-efficient irrigation: Prospects and difficulties of innovative practices. Agriculture Water Management, 146, 84-94
xv. Hargreaves, H.G., Mekley, G.P. 1998. Irrigation Fundamentals. Water Resource Publication, LLC, 200 Pp
xvi. Maurya, Ashok .Kumar & Indira Dutta. (2015). Fluoride Menace in Groundwater: A Study of North Gujarat, Allied Publishers Pvt. Ltd., New Delhi